A066984

VOL II

(6) U. S. ARMY METRICATION: ANALYSIS AND RECOMMENDATIONS FOR DA IMPLEMENTATION PLAN.

VOLUME I.

(12) 340 p.

(11) 9 Jun 78

(15) CONTRACT DAAG 39-77-C-0108

Prepared by:

(10) M. J. Cetron,
L. A. Roepcke,
C. F. McFadden,
S. E. Sugarek
E. B. Peters

Forecasting International, Ltd.
1001 North Highland Street
Arlington, Virginia 22210

June 9, 1978

390 586

79 04 02 03

Point Paper

U.S. Army Metrication: Analysis and Recommendations for DA Implementation Plan

SITUATION

1. Metrication -- conversion to SI -- in the U.S. and the U.S. Army is inevitable.
2. Driven by international economics, U.S. industrial conversion is progressing within each sector at a rate responsive to customer demands; conversion will be substantially accomplished in the decade 1980-1990.
3. The rate of industrial metrication is accelerating; the Army cannot remain unaffected as its suppliers increasingly adopt SI.

VALUE TO THE ARMY

4. Metrication will enhance standardization with NATO and other allies. It will directly support the NATO RSI program.
5. Metrication benefits will be profound, but are generally long-term.
6. The process of rationalization and standardization of varieties, sizes and procedures, made possible by metrication, will ultimately result in reduced costs to the Army.

CAUTIONS

7. There are no insuperable metrication problems. However, conversion is complex; metrication will affect every facet of the Army. Detailed planning will be required.
8. There are short term costs associated with metrication, but foreign and domestic experience show that effective management can keep costs small.
9. There is a potential for disrupting operations and incurring unnecessary costs during the transition to SI; a reasonably short transition period will minimize these risks.
10. The longer Army conversion is delayed, the more costly it will be.

POLICIES

11. An evolutionary, benefit-oriented conversion, with least cost and minimum disruption of operations as guiding criteria, will permit the most effective Army transition.
12. Army conversion in all activities at once, but at rates suited to each, and in harmony with industry will prove least costly and disruptive.
13. Successful conversion is contingent on effective planning, coordination, and communication at all organizational levels.
14. Metrication should not alter existing responsibilities or authority delegations for materiel acquisition. Therefore, related metrication planning must be done -- indeed, can only be done -- by those who will make the conversion a reality.
15. To support metrication by line managers, to initiate actions to solve metrication problems which cross organizational lines, and to recommend DA metrication policies, a metrication organization will be required. Although this organization should be predominantly ad hoc, a DA Metric Coordinator with a small, dedicated staff will be necessary.

ACTION

16. Issue a statement of positive commitment to the conversion of the Army to the metric system.
17. Assure that metrication is properly and consistently considered at decision points in the system acquisition process.
18. Take other appropriate steps to initiate the Army metrication program.

Page 206 is left blank intentionally

Executive Summary

Over the year's effort, much has been learned about the metrication experiences and practices of foreign nations and U.S. companies. In developing the recommendations on an appropriate Army Metrication Organization and Implementation Plan, we have drawn heavily upon the lessons learned from the experience of others.

The most crucial lessons learned from the experience of others which have relevance to the U.S. Army are briefly summarized below.

1) Metrication is inevitable.

2) Key to the Army's approach to metrication should be an evolutionary, least cost philosophy - including the concepts of keeping pace with industry, letting costs lie where they fall and employing flexible timetables and plans.

3) A strong, high level commitment to metrication is essential.

4) Planning and coordination are the keys to successful, least cost metrication, and the "doers" (line management) should be the planners.

5) Only a small, dedicated metrication organization is needed. It can be supported by ad hoc working groups with membership drawn from the line organization.

In addition to an analysis of the experience of others, it is essential to evaluate DODD 4120.18, Use of the Metric System of Measurement. The analysis reveals that the content and intent of DODD 4120.18 are not inconsistent with the tenets of successful metrication. Having reached this conclusion, we derived a statement of the U.S. Army Metrication Mission from the directive. A statement of the mission and an understanding of the supporting objectives are essential to the development of an appropriate organizational structure and implementation plan. The U.S. Army Metrication Mission is as follows:

The Department of the Army will consider the use of the metric system in all of its activities consistent with operational, economic, technical, and safety requirements, in order to accept industry conversion with minimum cost and disruption of operations, and to foster standardization with our allies.

In order to satisfy or achieve the U.S. Army's metrication mission, any number of strategy options are available. The spectrum of reasonable options are investigated and an optimum strategy, presented below, has been developed. The recommended strategy for U.S. Army metrication is:

Capitalize on metric conversion by adopting metrics as practicable in all Army activities, preparing for an accelerated metric transition, and, when appropriate, promoting national metrication where advantageous to the Army.

At this point we have broadly defined what is to be done and how it is to be done. Substantial analysis of foreign and domestic experiences and practices provide additional insight into how best to accomplish metrication. The next step is to develop an organizational structure and an implementation plan which will be best suited to Army needs.

In executing metrication tasks, extant organizations have major decision-making roles in the day-to-day aspects of metrication. In structuring the extant organization's metrication tasks, the approach adopted has been to define tasks to include all of those things which must be accomplished (or evaluated) to achieve the U.S. Army's metrication objectives. Tasks under each objective generally address the following issues: Policy; Guidelines; Planning/Coordination/Communication; Documentation; and Resource Allocation. Because the decision-making takes place at many organizational levels, the task statements are broad.

With respect to metrication, the line managers will require guidance and support in accomplishing their metrication tasks. This is the function of the Army Metrication Organization. The major recommendations with respect to the Army's metrication organization are as follows:

1. Primary responsibility for U.S. Army metrication should be assigned to the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA).

2. DARCOM should be assigned the "lead department" role, and CG DARCOM should be delegated major Army metrication responsibilities.

3. A high-level, dedicated metrication organization consisting of the following elements should be established:

   a. A high level metric policy group, referred to as the DA Metric Advisory Group (DAMAG).*

      (1) The major functions of the DAMAG would include:

         (a) Define Army metrication goals and directions;

         (b) Develop and recommend metrication policies;

         (c) Approve Army metrication plans;

         (d) Review proposed revisions to metrication plans;

         (e) Provide top level support and commitment to Army metrication efforts;

         (f) Review Army metrication progress on a periodic basis;

         (g) Provide advice and guidance on metrication issues to both higher and lower level management.

      (2) Membership on the DAMAG should include: Deputy Chief of Staff for Logistics; Deputy Chief of Staff for Operations and Plans; The Comptroller of the Army; The Surgeon General; Chief of Engineers; Commanding General, U.S. Army Materiel Development and Readiness Command (Chairperson); Commanding General, U.S. Army Training and Doctrine Command; Army Metric Coordinator; Deputy Chief of Staff for Personnel*; and The Adjutant General*.

---
*Conditional: Should sit on Group when matters of legitimate interest are being considered.

b. The DA Metric Coordinator (DAMC), supported by a small dedicated staff to assist the DAMC. The DAMC and his staff are the DA Metric Office (DAMO).

(1) The DA Metric Coordinator (DAMC) and his staff, which constitute the DA Metric Office (DAMO), would have major responsibility for the day-to-day aspects of managing metrication in the Army. The major roles of the DAMC and the DAMO would be:

(a) To provide information and recommendations to the DAMAG, serving as secretariat to the Group.

(b) To facilitate metrication by serving as an information clearinghouse and coordinating body.

4. CG DARCOM should chair the DAMAG and report directly to DCSRDA as Chairperson of DAMAG.

5. The DAMC should report directly to the Chairman of the DAMAG.

6. Physically, the DAMO should be located at HQ DARCOM.

The organizational placement and relationship of DAMO to the other Army organizational elements is depicted in the schematic on the following page.

As the discussion above indicates, there are several key metrication actions in the U.S. Army, and each of these actions has specific tasks to be performed to initiate the recommended strategy. The major thrusts of the tasks for each action are presented below.

Army Member of the DoD Metrication Steering Group. As the only readily identifiable position (individual) with a title which indicates legitimate interest in Army metrication, the Army Member of the DoD MSG will initially be personally concerned with creating an awareness of the impending nature of metrication, especially at high organizational levels.

DCSRDA. DCSRDA, at least initially, will focus on establishing and promulgating commitment to metrication and on providing guidance to the Army metrication organization.

CG DARCOM. CG DARCOM will be involved in establishing the metrication organization within the terms of AR 700-1.

Chairperson, DA Metric Advisory Group. The Chairperson's initial tasks will be to prepare for and conduct the initial meeting of the DAMAG.

DA Metric Office. The DAMO (and the DA Metric Coordinator) will be heavily involved in creating an awareness of commitment to metrication, establishing communication and coordination networks and providing support to the DAMAG.

To date, the Army has demonstrated concern with metrication and has taken the preliminary reasonable steps. However, Army metrication has, thus far, occurred on an unplanned, uncoordinated basis. As national metrication accelerates, the lack of planning and coordination can be costly. Today, the Army is in a favorable position; initial metrication steps have been taken and

metrication is being accommodated in numerous projects, but detailed planning and good management are required to ensure a cost-effective conversion.

The Army's metrication tasks are complex because among other things, the Army is geographically dispersed, uses a great number of products and services, is large in size, and must maintain operational readiness. Metrication will also affect all elements of the Army. Therefore the planning and coordinating tasks are substantial. A firm, high level commitment within the Army must be established to support the detailed planning and good management that are required for a cost-effective conversion.

TABLE OF CONTENTS

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

CHAPTER 1

INTRODUCTION

The purpose of this document is to convey the recommendations for an Army Metrication Organization and Implementation Plan.
The options explored and recommendations made in this report are based on a detailed analysis of foreign national and U. S. industrial metrication experience and its applicability to U. S. Army goals, objectives and constraints.

Over the period of a year, a large amount of data, both quantitative and experiential, has been collected and analyzed. The problem, with respect to the final report, was to distill this information to a reasonable volume. In producing this report, inclusion of sufficient substantiating data was required in order to support the conclusions and recommendations. In structuring the final report, it was necessary to limit the background discussion to key elements and lessons learned. The Tasks A and B Reports, on Foreign Metrication Experience and Domestic Metrication Experience, respectively, provide much greater detail on the issues discussed in this report.

The development of the recommendations provided was an iterative process. Specific areas and interrelationships have been repeatedly assessed as new information and additional insight has been gained. A major conclusion which has been confirmed throughout the study is that metrication is mainly a management problem. The day-to-day aspects of metrication should be handled by individuals with normal line responsibility and authority. Thus the recommendations included here focus on higher level management and the tasks they must perform.

The organization of the report represents the analytical process employed to reach a set of recommendations for an Army Metrication Organization and Implementation Plan. It must be borne in mind that the analytical procedure was iterative and the report cannot illustrate the iterations that have occurred.

Chapter 2, Mission Analysis, explores the Army's mission and objectives with respect to metrication. The analysis focused on the terms of DoD Directive 4120.18, Use of the Metric System of Measurement, since DoD policies will bound the Army's metrication policies and activities. Issues explored included the consistency of the policies and objectives of DoDD 4120.18 with foreign and domestic policies and practices, and the inclusion of sufficient flexibility to allow a minimum cost conversion. The conclusion drawn was that the DoDD 4120.18 is acceptable without modification as a basis for Army metrication planning. A broad mission statement was developed, based on the Directive, the philosophy being that until the mission is clearly defined, strategy and supporting organization and implementation plans cannot be developed. The objectives specified in DoDD 4120.18 were extracted and grouped to facilitate analysis in the later phases of the study.

Chapter 3 provides an overview of the external environment. Metrication is an activity which cannot be undertaken independently by the Army. To assure a minimum cost conversion, Army plans and policies must be compatible with industry plans. It is also essential that the forces leading to metrication be recognized and considered in the Army planning process. This chapter attempts to summarize the key elements and environmental forces regarding metrication. A major conclusion of the earlier analysis in this study is that metrication is inevitable. This chapter highlights the factors which lead to this conclusion.

Through the investigation of foreign and domestic metrication experiences, a number of key issues and lessons have emerged which have significance for the U. S. Army in planning and executing its conversion to metric. Chapter 4, Lessons Learned, provides concise

discussions of the elements which the study team believes are critical to Army planning. The key issues fall into four categories: The Metric Conversion Environment; The Philosophy of Conversion; The Conversion Process; and Some Major Details. The lessons learned are substantiated here; they provide the major bases for recommendations included in the final chapters.

The first four chapters provide the framework for analysis. They summarize the mission, the environmental influence, and what we know (i.e., lessons learned). The final chapters draw upon these elements in order to develop a strategic plan for Army metrication.

Philosophically, once the key factors are recognized and assessed and a framework developed, we can proceed to develop a strategic plan. Within the framework, however, there are generally several options as to the strategy to be employed in attaining the mission and its supporting objectives. Therefore, the range of strategy options must be identified, conceptualized (or defined) and evaluated or tested. Chapter 5 focuses on these issues and culminates with the recommendation of a strategy for achieving metrication which appears optimum within the limits imposed by the framework.

With a strategy in hand, an evaluation of the what, how and who of metrication can be made. These issues are addressed in Chapters 6, 7 and 8.

A major lesson learned in the course of this study and mentioned briefly above is that the line managers will make the decisions on metricating a particular item, product, etc. The purpose of Chapter 6 is to define broadly the tasks which the line management has to accomplish in metricating. The focus is to highlight the major types of tasks and the questions which the line manager should answer in making his decisions on metricating an item.

While the line people will be the decision-makers with respect to the day-to-day aspects of metrication, they will require support to make metrication decisions effectively. Both foreign and domestic experiences have demonstrated the value of a small, dedicated

metrication staff to coordinate, communicate and generally facilitate metrication. Chapter 7 presents the rationale for an Army metrication staff and recommendations on the organizational placement and physical location of that group (i.e., Army Metric Office).

Chapter 8 contains the Implementation Plan. The implementation plan consists of the initial tasks for each of the major Army metrication actors.

The second volume of this report includes a number of annexes containing more detailed information and support data on various topics of interest. In addition, the reader is referred to the Tasks A and B Reports where more detail is required. Task A Report: Foreign Experience contains a collection and synthesis of data and subjective metric conversion experiences in Sweden, Israel and Australia. A survey of the literature provided additional information on metrication experiences of other countries. Task B Report: Domestic Experience focuses on data and subjective metrication experience in the national, industrial and military sections of the U.S. The report documents metrication experiences, problems, solutions, and plans in each of these sectors.

CHAPTER 2

MISSION ANALYSIS

The purpose of this chapter is to assess the adequacy of the governing objective[1] gleaned from DOD Directive 4120.18, as a planning basis. The Directive is then explored in order to frame a formal Department of the Army metrication mission statement, identify metrication objectives, and develop an understanding of the spirit of the Directive. The mission analysis provides the basis for all subsequent steps in the planning process; most importantly, it provides the criterion against which to test the tentative Army metrication strategies developed in Chapter 5.

In developing a metrication plan for the U.S. Army, the first step, as with any plan, is to derive the commander's mission -- his task and purpose. The principal references, from which the Army metrication mission may be derived, are DoDD 4120.18, and the Metric Conversion Act of 1975 (PL 94-168; See Annex B). PL 94-168 serves as the legal basis for DoDD 4120.18 which contains some of the same language such as "increasing use of the metric system." Although DoDD 4120.18 treats other metrication matters of pertinence to DoDD, the Law provides insights into the limits which constrain DoDD 4120.18 and any action taken pursuant to it. Further, reasoning that development of a viable Army plan would be impossible if the governing DoDD 4120.18 were found to be seriously flawed, the principle tenets of DoDD 4120.18 were compared with those of foreign organizations and U.S. companies with successful metrication experience. To obtain

1. Department of Defense Directive 4120.18, Use of the Metric System of Measurement, dated December 10, 1976 (See Annex E).

background information necessary for this comparison (and also for subsequent use in developing an Army plan), foreign and domestic sources were tapped by personal visits and correspondence, and by searching the open literature. This effort, documented in Task A (Foreign Experience) and Task B (Domestic Experience) reports, investigated, inter alia, the directives and policies which have governed the metrication programs of nations, military establishments, and industrial companies. Although the emphases may vary somewhat, depending on the particular organization and its state of metrication, the following characteristics of a successful conversion program are universally manifest:

- o Commitment to metric conversion at the highest organizational levels;
- o Motivation focused on realizing the benefits of metrication;
- o Metrication leadership by industry (i.e., economic interests):
- o An evolutionary, least-cost mode of conversion;
- o Wide participation by those who will be affected by the conversion;
- o Realistic and flexible metrication planning by those who will bring about the conversion;
- o Adoption of metrics in the design of new materiel;

None of the foregoing characteristics is inimical to or inconsistent with the tenets and policies expressed in DoDD 4120.18. However, while the Directive positively endorses or supports most of these characteristics, it does not emphasize participation or flexible planning, nor does it affirm a commitment to metric conversion. The latter shortcomings (which may be rectified by time or circumstances) not withstanding, it is concluded that DoDD 4120.18 provides an adequate basis on which Army metrication planning may be predicated. The following statement of the DA Metrication Mission is derived from this assessment and review of DoDD 4120.18:

The Department of the Army will consider the use of the metric system in all of its activities consistent with operational, economic, technical, and safety requirements, in order to accept industry conversion with minimum cost and disruption of operations, and to foster standardization with our allies.

It is not possible to capture in a few words all of the policies contained in the Directive. These policies, however, are essentially objectives which are implicit in the mission statement and necessary to an understanding of it. Because the objectives (policies) are not mutually exclusive, and because they address several levels of importance, any aggregation of the objectives to a smaller, more manageable number is somewhat arbitrary. A reasonable aggregation is given in Figure 2-1 for ease of reference and use elsewhere in this study. The mission statement, with the objectives, provides the requisite focus for development of an Army metrication plan.

Other significant factors must also be recognized in order to appreciate the setting in which DoDD 4120.18 is embedded. One of these is the fact that Army metrication must affect other elements of the Department of Defense. The Army is one of 11 DoD Components;[2] it comprises approximately 37%[3] of the total military and civilian manpower of DoD; approximately 28%[3] of the defense budget is appropriated for the Army; and the Army provides many common items of supply to other DoD Components. Army metrication plans, programs, and actions cannot, as a consequence, fail to affect metrication within DoD as a whole. Army metrication in harmony with other DoD Components will directly and significantly contribute to DoD metrication; conversely, an Army conversion program uncoordinated with other DoD Components, or at cross purposes with them, will have a devestating effect on DoD metrication in terms of operational

---

2. As defined in DoDD 4120.18 and U.S. Government Manual, 1976/77. page 161.

3. U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the U.S., 1977, Tables No. 567 and 584.

FIGURE 2-1

CATEGORIZATION OF DoD/DA METRICATION OBJECTIVES

The following objective statements are extracted from DoDD 4120.18. The numbers in parentheses given at the end of each statement refer to paragraphs in the Directive.

1. DoD/DA metric transition in harmony with industrial conversion (IV-D).

    a. Enhanced defense-industry preparedness or readiness (V-B4).

    b. Acceptance of new materiel of metric design when production facilities are available (V-B3).

    c. Acceptance of industry conversion with minimum cost (IV-A).

        (1) Realization of economic, operational, or other advantages occasioned by acquisition of metric materiel (V-B5).

        (2) No unnecessary retrofit of existing customary systems (V-D).

        (3) Metric development or conversion of military specifications, standards, and other documentation on a routine basis in harmony with industrial changes (V-K).

    d. Acceptance of industry conversion with minimum disruption of operations (IV-A).

        (1) Unimpaired interchangeability and interoperability of hybrid items (V-C).

FIGURE 2-1 (Continued)

(2) Appropriately and adequately trained user personnel (V-M).

2. Standardization with our Allies (IV-B).

a. New materiel of metric design for Allied use, and for foreign military sales and joint production (V-B1 & B2).

b. Participation, to the extent of Dod interest, in the development of national and international metric standards; adoption of international metric standards which meet or exceed definitions and restrictions established by U. S. standards (V-J).

3. Metric usage in all activities consistent with operational, economic, technical, and safety requirements (V-A).

a. Metric usage for designs of new material (IV-C, V-B).

(1) Consistent consideration of metric impacts on major systems acquisition by the DSARC (V-F)

b. Metric usage in the procurement of all supplies and services (V-B).

(1) Specification of direct measurement features for new equipment purchased in either SI or dual units (V-L).

c. Orderly programming and budgeting actions which support the transition to SI (V-H).

d. Adherence to accepted SI units (V-I).

(1) The use of metric or dual units in technical reports, studies, and position papers (V-G).

(2) Drawings exhibiting only one system of units on the views (V-N).

readiness and cost. The Army conversion must therefore be compatible and coordinated with other DoDD Components, including OSD.

Timing considerations are important. The requirement that DoD keep pace with industrial conversion establishes both the initiation date, and the rate of DoD/Army conversion, within approximate limits. Industrial conversion has been progressing, among some industries, for several years; the trend towards metrics is currently accelerating. Industrial metrication, however, has not yet reached the point of directly and consistently impacting the DoD/Army acquisition process, i.e., materiel and parts continue to be available in customary units at no cost or other penalty. While there is little indication that industrial conversion will progress (in the very near future) to the point that such a penalty would be incurred, this situation will not continue indefinitely. Industrial sectors are converting at different rates. In a very few years, for instance, inch-pound cars will cease to be produced; the aerospace industry will take longer to convert. Thus, while there is no need to implement a crash DoD/Army metrication program, the large size, organizational complexity, and the wide variety of military materiel, which collectively constitute the DoD and the Army, indicate that effective preparation for the transition will require a considerable period of time. For this reason, such preparation should commence without delay.

The duration of the metric transition is another timing factor which warrants recognition. While the DoD/Army is constrained to keep pace with industrial conversion, considerable flexibility in the rate of conversion remains because transitioning companies will retain dual capability (to some degree, and for some time), and conversion rates among industries and companies will vary. Foreign national and domestic industrial experience indicates that, once started, metrication costs are minimized by making the transition period as short as practicable. It would therefore appear to be in the interest of the DoD/Army to proceed, after initiating the transition, with all deliberate speed.

In addition to economic considerations, the political metrication environment, which circumscribes DoD/Army metrication, is beginning to evolve.

- The Administration has taken no official position on metrication. The President and the Secretary of Defense have, however, focused military attention on Europe and endorsed improved compatibility of U.S. - NATO materiel; the potential for metric impact is major.

- Although the U.S. Metric Board members were confirmed on March 21, 1978, many months must elapse before the Board can become functional; its power and influence cannot be inferred from the law (PL-94-168).

- An Interagency Committee on Metrication Policy is in the formative stages. It is envisaged that this Committee would resolve differences among Federal agency metric programs, provide executive branch liaison with the U.S. Metric Board, and recommend conversion plans and policies for the Federal government where more than one agency has a primary interest. 4

In addition to the foregoing factors, the nature of the mission must be considered. The Army metrication mission (including the objectives) is both strategic and tactical in nature. A strategic plan for its implementation should be broad enough to embrace major considerations and actions of a policy nature, general enough to remain viable during the transition years, yet specific enough to provide useful guidance at three levels of Army command, namely: HQDA, Major Army Command (MACOM) and Major Subordinate Command. With a strategic plan in effect, the necessary detailed metrication planning at all appropriate levels can then proceed.

The plan should also be compatible with DoD Directives and guidance, and with the metrication plans of other DoD Components. DoDD 4120.18

4. <u>Metric Reporter</u>, February 3, 1978 and April 14, 1978.

is applicable to other DoD Components in the same manner and to the same extent that it is to the Army. All Components are at approximately the same state of metric awareness, involvement, and preparation. While some facets of metrication may be unique to each Component, the Components are largely interdependent because they use much common equipment. Some Services provide specific items of equipment to all the Services (e.g., the Army provides small arms to the Air Force and Navy). Moreover, all Components, particularly the Services, are also markedly interdependent operationally. For these reasons, metrication policies, plans, and programs among the components must be compatible and coordinated.

In the military planning process it is customary, and necessary in a combat situation, to identify the enemy and his objectives. There is no "enemy" in the usual sense, in the case of metrication. However, there are actions and conditions which prevent an instantaneous transition to SI. For planning purposes, it will be useful to define the "enemy" as the anti-metric (active or passive) environment. The objective of the "enemy" is to prevent or inhibit changes to the measurement system, i.e., to maintain the status quo--the customary measurement system.

In summary, the metrication mission analysis has established that DoDD 4120.18 provides an adequate basis for a strategic Army plan. An Army metrication mission statement has been framed; objectives have been identified and categorized in a useful form. The relationship of Army-DoD planning has been explored and the inter-dependence noted. Timing considerations affecting Army metrication (transition initiation, rate, and duration) have been recognized. The major impediments to Army metrication will be the pervasive and entrenched nature of the existing measurement system, and human reluctance to change. For ease of reference, key points of the metrication mission analysis are summarized below.

1. The Army Metrication Mission.

The Department of the Army will consider the use

of the metric system in all of its activities consistent with operational, economic, technical, and safety requirements, in order to accept industry conversion with minimum cost and disruption of operations, and to foster standardization with our allies.

2. <u>Global Metrication Objectives</u>

   a. DoD/DA metric transition in harmony with industrial conversion.

   b. Standardization with our Allies.

   c. Metric usage in all activities consistent with operational, economic, technical, and safety requirements.

3. <u>Other Significant Points</u>

   a. Plan now for metrication while time is available.

   b. Keep pace with industrial metrication.

   c. Plan for an Army metric transition period that is as short as practicable.

   d. Accomodate changes in the political metrication environment.

   e. The plan is strategic in nature; it should be broad (Army-wide), general (viable through transition); it should provide useful policy guidance.

   f. The plan should aim at the MACOM organizational level, and one echelon above and below that level.

   g. The plan should be compatible with other DoD Component planning and OSD guidance.

CHAPTER 3

AN OVERVIEW OF THE STATUS OF METRICATION

3.1 International

Since the 1960s, when the 11th General Conference on Weights and Measures agreed on the International System of Units (SI), there has been a general and accelerating trend among the nations to adopt the system. As is expected, the conversion to SI by nations with a metric tradition has not proved traumatic. Among nations with inch-pound traditions, conversion has required greater attention and planning, but even in these cases most nations are in the final stages of a smooth transition.

The need for a common international measurement language is driven by economics, particularly the economics of world trade. Many countries including the U. S. are increasingly more dependent upon international trade to secure the goods required to enhance the standard of living, provide national defense, fuel national industries, etc. This greater dependence on foreign trade is a driving force behind the conversion to SI. Conversion to SI may facilitate international trade and boost a country's position in the world market.

Figure 3-1 lists the major trading partners for the U. S., Australia, Canada, Finland, Israel, New Zealand, South Africa, Sweden and the U. K. It is interesting to note that the five countries to which the U. S. exports the largest portion of its goods (Canada, Japan, FRG, Mexico and the U. K.) are all either using the SI system or are in the process of converting. Similarly, the countries from which the U. S. obtains the majority of imports are SI or are converting. The implication of the trend toward worldwide adoption

FIGURE 3-1

PRINCIPAL TRADING PARTNERS[1] (1975)

Country	Import	Export
U.S. (IP)	Canada (I/SI) Japan (SI) *FRG. (SI) *U.K. (I/SI) Venezuela (SI)	Canada (I/SI) Japan (SI) *FRG. (SI) Mexico (SI) *U.K. (I/SI)
Australia (I/SI)	U.S. (IP) Japan (SI) *U.K. (I/SI) *FRG. (SI) Canada (I/SI)	Japan (SI) U.S. (IP) *U.K. (I/SI) New Zealand (I/SI) *FRG. (SI)
Canada (I/SI)	U.S. (IP) *U.K. (I/SI) Japan (SI) Venezuela (SI) *FRG. (SI)	U.S. (IP) Japan (SI) *U.K. (I/SI) *FRG. (SI) *Italy (SI)
Finland (m/SI)	USSR (m) Sweden (m/SI) *FRG. (SI) *U.K. (I/SI) U.S. (IP)	USSR (m) Sweden (m/SI) *U.K. (I/SI) *FRG. (SI) Norway (m)
Israel (1974) (m/SI)	U.S. (IP) *FRG. (SI) *U.K. (I/SI) *Italy (SI) *Netherlands (SI)	U.S. (IP) *U.K. (I/SI) *Netherlands (SI) *FRG. (SI) Hong Kong (I)
New Zealand (1974) (I/SI)	Australia (I/SI) *U.K. (I/SI) Japan (SI) U.S. (IP) *FRG. (SI)	*U.K. (I/SI) U.S. (IP) Japan (SI) Australia (I/SI) Canada (I/SI)
South Africa (I/SI)	*U.K. (I/SI) *FRG. (SI) U.S. (IP) Japan (SI) *France (SI)	*U.K. (I/SI) Japan (SI) U.S. (IP) *FRG. (SI) *Bel.-Lux. (SI)
Sweden (m/SI)	*FRG. (SI) *U.K. (I/SI) *Denmark (SI) Norway (m) U.S. (IP)	Norway (m) *U.K. (I/SI) *FRG. (SI) *Denmark (SI) Finland (SI)
U.K. (I/SI)	U.S. (IP) *FRG. (SI) *Netherlands (SI) *France (SI) *Ireland (I/SI)	U.S. (IP) *FRG. (SI) *France (SI) *Netherlands (SI) *Ireland (I/SI)

* = EEC member

1 = The parentheses following the country name indicates the measurement system in use in the country in 1975.

Abv.: SI = International system of units

m = metric (non-SI)

I = Imperial

IP = inch-pound system.

Sources: Listed on the following page.

SOURCES FOR FIGURE 3-1

1. U. S. Department of Commerce, Bureau of the Census, Statistical Abstracts of the United States, 1976 (Washington, D. C.: U. S. Government Printing Office, 1976).

2. Organization of Economic Cooperation and Development, Labor Force Statistics (Paris: OECD, 1975).

3. World Bank, World Tables, 1976 (Baltimore: The Johns Hopkins University Press, 1976).

4. United Nations, Yearbook of International Trade Statistics, 1975 (New York: United Nations Publishing Service, 1976).

5. International Labour Office, Year Book of Labour Statistics, 1976, (Geneva: ILO, 1976).

6. U. S. Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfer 1966-1975 (Washington, D. C., 1976).

of SI is that, eventually, the U. S. will need to make the conversion to maintain its position in the world market.

An industry-by-industry analysis of U. S. trade will provide some insights into those industries that are most likely to lead conversion and those that are familiar with the problems associated with working in two measurement systems. The Table in Annex A summarizes total shipments by industry in the U. S. in 1975. Imports and exports as a percentage of total shipments are also included in the analysis. These statistics given an indication of the industries where foreign trade (either import or export trade) is particularly important. They also give some indication of where multiple measurement systems may have the largest impact on U. S. industry.

As the analysis indicates, there are several industries where imports constitute a substantial portion (greater than 20%) of the total shipments. Among those industries with the highest proportion of imports are: Primary Metals-Primary Zinc, Textile Machinery, Shoes, Wood Pulp, X-ray and Electro-Medical Equipment, and Steel.

Exports constitute a significant portion of shipments in several broad sectors of industry including: Special Industry Machinery, Instruments for Measurement, Analysis and Contracting, elements of the Medical and Dental Instruments and Supplies Industry, the Aerospace Industry, several elements of the Chemicals and Allied Products Industry, and the Power Equipment Industry. A number of these products are somewhat measurement sensitive and the majority are being shipped to countries which use SI. As the worldwide use of SI becomes required as part of foreign trade, it is probable that these particular industries will be more responsive than those less dependent on foreign trade.

Penetration of foreign markets (both sales and production) by U. S. companies is having a profound metric impact on those companies. In sales, the customer prefers or requires metrics to be used. In production, the alternative to metric usage (where not prohibited) would involve costly training of the indigenous work force in the inch-pound system.

The impact of metrication on international trade is becoming progressively more apparent; import prohibitions by South Africa (in 1970) and Australia (in 1978) regarding non-SI measurement devices and gauges are examples. Furthermore, while dual labeled goods imported by these countries are still generally acceptable, the lists of commodities which must be packaged in preferred metric sizes are increasing. In other words, soft conversion/dual labeling is authorized as a temporary measure; the day will soon come, however, when virtually all imports will be SI-labeled and packaged in preferred metric sizes. Similar prohibitions are being raised by the European Economic Community (EEC) on the premise that the use of common measurement units, and supporting measurement devices and metrology, facilitates the free movement of goods within and into the Community; non-SI gauges are inimical to this concept. Furthermore, from 21 April 1978, SI will be required for all EEC commercial transactions. The use of most Imperial units in EEC trade will be prohibited after 1979.[1] Soft conversion of measurements to SI will satisfy EEC requirements; dual dimensioning, if considered confusing by an importing country, may be prohibited, however. Considering that the EEC accounts for approximately 28%, or $32B , of U. S. exports annually (1976),[2] the impact of EEC metrication policies on the United States becomes obvious.

The metrication status of Canada is particularly relevant to the United States. Approximately 23% ($22B) of U. S. imports come from Canada;[3] U. S. exports to Canada are also approximately $24B (21% of total exports).[4] The Canadian transition, begun in 1970, is expected to be essentially completed by the end of 1980. Mutual U. S.-Canadian interdependence tends to complicate Canada's conversion since some Canadian industry conversion plans must remain compatible with their U. S. counterparts. Canadian conversion would be facilitated if the U. S. were also converting, or converting on the same timetable.

In recent years foreign investment and sales penetration of U. S. markets have shown a dramatic increase. Acquisition of manufacturing plants by European and Japanese companies may mark a trend of some metric significance. It is not unreasonable to expect that foreign-based companies will exert a metric influence as the volume of foreign metric products manufactured and/or sold in the United States increases. Soft conversion (SI to inch) may continue, however, until metrics become accepted by consumers.

The impact of metrication on foreign military sales, and joint military production programs, is increasing, particularly with respect to Europe, where NATO and EEC memberships overlap. Metric nations which must buy military hardware will continue to buy "the best" systems, metric or not. Acceptance of inch systems, however, prolongs and aggravates all the problems associated with dual measurement systems, and inch military systems tend to become less and less attractive for this reason. If the U. S. retains customary units which is a complicating factor in joint development/production efforts, at a time when there is increasing use of international standards among metric nations, the scope of joint U. S./ foreign efforts will become more and more limited.

To summarize: the world is going metric, largely for economic (international trade) reasons. With a common measurement language approaching universal use, the pressure on the United States to conform is increasing. This pressure is fundamentally economic, but secondary effects are becoming apparent in other spheres, such as in military systems for Allied use. To retain its position in the world market, the U. S. will eventually have to convert.

3.2 Domestic

The guidance for U. S. metric conversion comes from the "Metric Conversion Act of 1975" (See Annex 2). This Act declares "a national policy of coordinating the increasing use of the metric system in the United States and establish[es] a United States Metric Board to coordinate the voluntary conversion..." The Act specifies several

types of responsibilities of the Board including consultation and cooperation with concerned parties and provision of public information and education programs.

The Act is the result of compromise and contains no deadlines or timetable. The U. S. Metric Board (USMB) has no compulsory powers. The partial list of nominees to the Board, submitted by President Carter to the Senate, was confirmed on March 21, 1978. At its first meeting, in early April of 1978, the USMB unanimously adopted the following resolution:

> *The U. S. Metric Board has noted the substantial contributions of the American National Metric Council in providing leadership in the private sector for managing the increasing usage of the metric system in business and industry. The U. S. Metric Board hereby records its position that the continued contribution of the American National Metric Council is a necessary ingredient of an effective total program in the United States.*[5]

The resolution indicates that ANMC will continue to play a strong role in U. S. metric conversion.

It is generally hoped that the U. S. Metric Board will be active and influential but there is no basis upon which to estimate the probability of this. The relative power, prestige and influence of the U. S. Metric Board can make it a significant factor in the achievement of metric conversion in the U. S.

Foreign and U. S. industry conversion experience suggests that a national commitment is an essential ingredient to a successful, economical conversion. The U. S. Metric Board could be one focus of national commitment and could provide the essential guidance. The emergence of a national commitment to metric conversion could also come through declaration by the President and/or further legislation by the U. S. Congress.

Whether a national commitment at high government levels will emerge is a matter of speculation. (Note that economics, trade and U. S. industry may provide the impetus for such a commitment.) Currently,

metric conversion is not a major issue in the U. S. Congress and does not get the attention that may be warranted. Currently, at the national level, the American National Metric Council (ANMC) is the major coordinating and focusing organization for metric conversion. While ANMC fills a useful and necessary role, especially in view of U. S. antitrust laws, it does not have the status and potential influence, within certain sectors of the economy, of a government institution. As noted above, the First Resolution of the U. S. Metric Board commended the ANMC and endorsed its continued role in U. S. metrication.

While there is some uncertainty and hesitancy within the Federal government about instituting metric conversion activities, a recent issue of the Metric Reporter (February 3, 1978) notes that an Interagency Committee on Metric Policy, responsible to the Secretary of Commerce and Chaired by the Assistant Secretary of Commerce for Science and Technology, is now being formed. The Committee will be responsible for:

1) Resolving differences among Federal agency metric programs;

2) Providing executive liaison with the U. S. Metric Board;

3) Recommending conversion plans and policies for the Federal government in those areas where more than one agency has a primary interest (e.g., transportation, construction, consumer affairs).

The April 14, 1978 issue of the Metric Reporter listed the representatives appointed to this Committee. The announcement of the formation of this committee indicates that there is a growing concern within government over metric issues. Thus while interviews conducted by Forecasting International with government officials in 1977 in general indicated the desire to wait until the U. S. Metric Board became functional before proceeding, a framework for activity is being developed in anticipation of growing metric activities in the U. S.

The American National Metric Council (ANMC) has assumed a major role in facilitating metric conversion in U. S. industry. Under ANMC auspices, individuals with interest in a particular industrial sector have been able to meet and exchange thoughts on metrication. Through the ANMC Sector Committees, Industry Plans and Timetables for metric conversion are being developed. Currently it is envisioned that once ANMC approves the sector plan (through its review process described in Figure 4-15), the plan will be submitted to the U. S. Metric Board for approval. Through ANMC, several sector plans have been developed. These are discussed later in this chapter.

While little has been done in terms of legislation at the state level, many states have established study groups, steering committees, and similar groups to examine and/or coordinate metric conversion at the state level. In addition, a large majority of states have appointed metric coordinators to represent the states on the Interstate Metric Committee which is being formed by the Committee on Transportation, Commerce and Technology of the National Governors' Association. State legislation and legal issues are recognized as potential problems in metric conversion and mechanisms have been established for resolving some of these issues. The National Conference of Commissioners on Uniform State Laws has founded a Committee to Draft a Metric Act, which can be used as a model for all states, to remove legal barriers to metric conversion. The American Bar Association's Metric System and Commercial Transaction Committee is urging that states pass enabling legislation prior to major shifts and initiation of educational programs.

The education sector has been one of the most active sectors in the U. S. at the national, state and local levels. Under the Education Amendments of 1974 (P.L. 93-380), Congress authorized expenditures for metric education. In 1976, grants totaling \$2.1 million were awarded by the U. S. Office of Education (USOE) Metric Program to state and local education groups. Grants totaling more than \$2 million were awarded in 1977.

A number of states have developed detailed timetables for the implementation of metric education at all levels. The scope of education activities indicate that new entrants to the labor force will have adequate metric training in the near future.

In light of the fact that there is no strong national commitment to metric conversion, states have been very progressive in deailing with metric issues. A strong national commitment would enhance their abilities to implement metric conversion in coordination with national and industrial needs and plans.

In Task B of this study, FI conducted a survey of selected major Army contractors to determine metrication status and plans. The survey indicated that many of the Army contractors are at least considering the conversion to metric and a number have implemented conversion plans. To obtain a broader perspective of U. S. industry metric plans and activities FI has conducted a survey of open literature. The statistical results of this survey, and the sources of data are included in Annex C.

The most interesting result of this broader survey is that at least 59 of the top 500 U. S. manufacturing companies (based on the Fortune ranking) are in the process of converting to metrics--or exhibit significant metric capability. It is significant that these 59 companies account for nearly 36% of the total sales of all 500 companies. Six of the top ten companies are converting to metric (Exxon, GM, Ford, IBM, GE and Chrysler). These six companies alone account for about 22% of the sales of the top 500 companies.

What becomes clear from this analysis of industry behavior is that metrication is inevitable. Many of the influential companies in the U. S. are in the process of adopting metric. While the degree and scope of activity vary from company to company, the signs indicate eventual conversion.

While most companies are pursuing a policy of gradual conversion on an economic basis with no deadlines, several have set up timetables. Most companies that have established timetables expect conversion to be complete in the 1985-1990 period. This is significant to the Army.

In addition, our literature survey revealed several industries where metric capability and/or adoption is growing. Among these are the liquor and the metal working industries. The National Tool, Die and Precision Machining Association reports increasing demand for metric work and a survey of retail weighing scale manufacturers indicates the ready availability of metric scales and/or conversion devices for customary scales.

While this survey is not, by any means, exhaustive, it certainly indicates a broad move towards metrication of U. S. industry--or at least the potential for the provision of metric products without cost penalty. A conclusion that can be drawn from the survey and general knowledge of the economy is that as the major companies move toward predominant use of the metric system, the support and supplier companies will convert too. To illustrate this point, consider the automotive industry. All four of the major U. S. automobile manufacturers are well along in the metrication process. The automotive industry encompasses a significant portion of the national economy. (Note for example that GM has 40,000 suppliers.)[6] Clearly, as the "Big Four" go metric, suppliers must convert. By the mid-1980s the automotive industry will be essentially metric. The actions of this industry by itself will have a profound effect on national conversion.

A second industry which is making major strides in metric conversion is the computer industry. IBM, the largest company in the industry, estimates metric conversion will be complete by 1982 and Honeywell has announced similar conversion efforts although their target date is 1987.

U. S. companies exhibit follow-the-leader behavior in most industries. As the major company or companies in an industry announce plans to convert and implement plans, competitors follow quickly to remain competitive.

In addition to the move by individual companies to convert, several of the ANMC Sector Committees revealed tentative Sector Conversion

Plans at the Fourth Annual ANMC Conference in Atlanta, Georgia, April 3-5, 1978. Plans were provided by the Metals Sector Committee, the Instrument Sector Committee, the Motor Vehicles Sector, the Electrical Goods Sector, Construction and Agricultural Equipment Sector and the Power Generator Sector. The Metals Sector Plan is included in Figure 3-2. Other sector plans are contained in Annex D to indicate both the contents of a plan and the varying range of elements which must be considered in developing a plan for metric conversion.

Because the availability of appropriate standards is essential to metric conversion, U. S. industry has been quite active in developing metric standards in standards-writing groups, such as ASTM, and in providing inputs into the formulation of ISO standards. There is a definite trend towards trying to develop adequate international standards. For example the U. S. has been particularly active in developing the ISO standards for metric fasteners. GM's recent decision to abandon its M 6.3 x 1 fastener for the preferred size M 6 x 1 has cleared the way for adoption by ISO of the U. S. proposal for metric fastener standards. It also is indicative of the desire for rationalization and standardization worldwide.

In assessing the current and likely future status of U. S. industrial conversion, it is essential to examine the industry motivations. All companies surveyed cite economics as the motivation for metric conversion. These major companies, discussed above, are generally multinational and derive a significant portion of their income from foreign sales and production. Adoption of metrics enhances both foreign sales and foreign production (e.g., ease of communication, common standards, etc.). Another aspect of the issue is that, in the long run, despite some initial costs associated with metrication, companies expect metrication to provide substantial economic benefits through simplification of stocks, rationalization, standardization and an enhanced ability to compete in international markets. (Incidentally, most companies note that costs identifiable

FIGURE 3-2

ANMC METALS SECTOR--CONVERSION PLAN

ANMC METALS SECTOR

MAJOR ACTIVITIES LIST

This represents the first draft of a proposed Major Activities List for the Metals Sector Committee of ANMC. As succeeding drafts are prepared, a logic network will be developed which will contain additional information concerning expected conclusion dates of various major events.

1.01 - 01 MEASUREMENT UNITS

0101 Identify changes needed to AISI Metric Practice Guide
0202 Publish, distribute and promote All Metals Metric Practice Guide
0103 Review, revise, and expand Metric Practice Guide as necessary
0104 Identify appropriate commercial units and precision to be used
0105 Develop consensus between producer and user groups

1.01 - 02 VOLUNTARY STANDARDS AND CODES - TECHNICAL

0201 Identify use, testing, and tolerance standards to be changed
0202 Develop preferred sizes for metal products
0203 Establish degree of precision for product categories
0204 Establish standards conversion priorities
0205 Submit standards to appropriate standards bodies
0206 Monitor changes to standards
0207 Promote availability of metric standards

1.01 - 03 LAWS AND REGULATIONS

0301 Identify laws and regulations to be changed
0302 Establish liaison with ANMC Committee on Tariffs
0303 Establish liaison with ANMC Government Liaison Committee
0304 Establish priorities and recommend changes to legislation
0305 Develop and specify changes to tariffs
0306 Monitor progress of changes to legislation
0307 Make recommendations for new legislation as needed

1.01 - 04 SECTOR MANAGEMENT

0401 Identify all major sector interfaces
0402 Establish liaison with interdependent sectors
0403 Develop Sector Conversion Plan
0404 Circulate plan to metals producers, service centers, interested trade associations
0405 Update and revise plan
0406 Schedule conversion activities
0407 Submit Sector Plan to U.S. Metric Board
0408 Monitor and revise schedules and report progress of sector conversion
0409 Maintain information on status of industry conversion plans and activities

1.01 - 05 ORGANIZATIONAL PLANNING

0501 Appoint Metric Coordinator
0502 Prepare Metric Policy Statement
0503 Identify internal and external interfaces
0504 Obtain and analyze related Industry Sector Plan
0505 Review Industry Sector Conversion Plan
0506 Define Organization objectives and policies
0507 Prepare Organization Plan
0508 Submit Organization Plan status to ANMC Metals Sector Committee

1.01 - 06 BUSINESS SYSTEMS

0601 Determine units to be used
0602 Determine measurement sensitive active records
0603 Develop approach regarding required government records and forms
0604 Review with government agencies receiving records
0605 Change procedures manuals
0606 Specify and schedule changes to records
0607 Implement training program as needed
0608 Convert Organization record files to SI for future use
0609 Convert Business procedures

1.01 - 07 MARKETING

0701 Conduct marketing surveys to measure metric activity among customers
0702 Conduct new product surveys regarding metric designs
0703 Determine acceptability of preferred sizes
0704 Revise preferred sizes

1.01 - 07 MARKETING (Continued)

0705 Revise product literature
0706 Convert all external transactions to SI
0707 Convert industry statistics to SI

1.01 - 08 RESEARCH AND DEVELOPMENT

0801 Identify research and development projects affected
0802 Establish program for conversion of research and development activity

1.01 - 09 DESIGN AND ENGINEERING

0901 Provide metric training for effected engineering personnel
0902 Identify standards and procedures requiring change
0903 Develop revised engineering and drafting standards and computer programs in SI
0904 Assist in the metrication of products
0905 Establish contact personnel at various operations for dissemination of technical information
0906 Initiate revised designs as various operations are ready to accept them
0907 Identify present and future equipment needs

1.01 - 10 MATERIALS AND SUPPLIES

1001 Determine availability of metric materials and supplies
1002 Encourage suppliers to convert products and processes to SI
1003 Procure materials and supplies in SI units

1.01 - 11 PRODUCTION PROCESSES

1101 Identify equipment and tooling to be converted
1102 Identify process instructions to be changed
1103 Change and implement process instructions
1104 Begin production in metric

1.01 - 12 EQUIPMENT

1201 Identify equipment to be changed or modified
1202 Identify metric instrument, measurement, tool and scale needs
1203 Determine availability of items in (1202)
1204q Procure modification equipment or new equipment
1205 Schedule modifications to equipment
1206 Implement changes to equipment

1.01 - 13 INDUSTRIAL RELATIONS AND EMPLOYEE TRAINING

1301 Identify Industrial relations activities affected by conversion
1302 Identify training needs
1303 Identify changes to labor agreements
1304 Identify safety-related activities
1305 Develop training programs
1306 Implement new labor contracts
1307 Implement revisions to safety-related activities
1308 Implement training programs
1309 Monitor progress

1.01 - 14 PUBLIC AWARENESS

1401 Identify who needs to be informed of conversion activities
1402 Implement programs to increase awareness of these activities

as due to metrication are small*.) The need to compete effectively in international markets will persist and provide continued impetus to industrial metrication. It can safely be assumed that, eventually, U. S. industry will be metric whether or not a national commitment to metric conversion exists and when U. S. industry is essentially converted, the nation will follow or pay the costs to purchase customary-dimensioned items. If a national commitment were to exist at some future date, this would, however, enhance industry's ability to convert on an economical basis and allow a least-cost national conversion.

Several Army contractors surveyed by FI note that a military commitment to metrics would allow them to begin converting their military production facilities as they convert their commercial facilities. An implication that can be drawn from the foregoing analysis is that as U. S. companies become predominantly metric, they will be less and less willing to maintain a division which handles military work in customary units.

While U. S. industry activities are significant, public attitudes will also significantly affect U. S. metric conversion. Roper and Gallup polls indicate a high degree of awareness of the metric system in the U. S. but a low portion in favor of adopting it. These polls also indicate that most Americans have virtually no facility with the system. Until public education programs increase the functional ability of the public, there is likely to be considerable resistance to the change.

Experiences of foreign countries, including Australia and South Africa, indicate that getting the consumer involved early in conversion may be a very effective strategy. Numerous U. S. companies also indicate that their "metric awareness" programs have been slanted towards employees as consumers rather than as employees. Supporting the argument that consumer acceptance is very important is the U. K. experience where consumers have not been involved and have strongly resisted conversion. The U. K. conversion program is characterized as being unsuccessful.

Using grocery stores, retail stores and sporting events to introduce the consumer to metrics may be effective in gaining acceptance. In fact metric quantities are being introduced in a number of consumer goods areas such as soft drinks, liquor and clothing. But the movement is not widespread and many consumer goods companies express a strong concern that until there is a national commitment to metric conversion, corporate conversion will encounter strong resistance. The recent (May 1977) announcements by Sears, Roebuck & Company and Montgomery Wards & Company to convert all products to metric sizes by 1985, however, indicate that metrication in the consumer goods arena is growing.

While the key to public resistance is fear of the unknown and lack of experience in using the system, a real problem is evidenced. That is the fear that industry will use metric conversion as a means of masking unwarranted or excessive price increases. Metric sizes for liquor tend to be either slightly larger or smaller than customary sizes. In the case where a consumer gets slightly less but pays the same price as he would for a comparable customary size, the consumer senses being taken advantage of. This is a real issue that must be resolved by appropriate corporate pricing policies and a mechanism of appeal for the consumer where he feels that the price is excessive.

Labor also poses a barrier to metric conversion in the U. S. While there are, of course, irrational reactions to metric, labor has also surfaced some legitimate concerns regarding employment, promotion opportunities and the cost of replacing personal tools. The problems of employment, promotion opportunities and related issues have been dealt with by companies through the assurance of provision of appropriate training. The issue of who will bear the cost of personal tools has been resolved in the major automobile manufacturing companies, indicating that it is a solvable problem. Generally the company bears a part, if not all, of the cost of personal tool replacement. The unions are unhappy because the issue has become a bargaining point in contract negotiations and the unions

argue that this issue intrudes upon the union's chance for success in gaining other concessions--thus lessening their ability to secure the desired benefits for their members.

3.3 Military

Metric usage in the U. S. Army has a long history, at least in particular areas. For instance, hard metric units and measurements are used for cartography, artillery fire control, and firing tables; artillery and tube-fired anti-tank weapons are designed in soft converted metric units. The Army has made metric policy decisions regarding more than a dozen weapon system projects since 1970. Motivation for these decisions stems principally from a desire for standardization with allied nations. Most current metric projects are hybrid (inch and SI) designs. Two projects (Single Channel Ground and Airborne Radio Subsystem-VHF (SINCGARS-V), and Tractive Entanglement) are wholly metric. Metric design for the Advanced Attack Helicopter was evaluated and found to be too expensive. Metric decisions on six projects have been taken since 1975, indicating a rising trend. On balance, however, the Army (like the nation) predominantly uses the customary system of units.

In late 1973, the Metrication Panel of the Defense Materiel Specifications and Standards Board was established to formulate standardization actions needed to facilitate metric conversion. Activities of the panel have included an industry/DoD workshop to assess the status of industrial metrication in order to initiate needed metrication action within DoD. An interim metric policy, issued in June 1975, was revised and published as DoD Directive 4120.18 (See Annex 5), dated December 10, 1976. AR 700-1 (See Annex 6) dated June 7, 1977, implemented DoD policy within the Army and authorized the creation of a DA Metric Office within DARCOM. Concurrently, metrication groups and coordinators have been established at all Command levels.

Metrication planning is being undertaken by all groups although activity levels vary according to perceived needs for action, the metrication status and plans of associated industries, and the competing demands of other responsibilities on the members of these ad hoc organizations. In general, these groups reflect the national tempo of metrication activity. There are exceptions; TARCOM/TARADCOM is very active, associated as it is with the automotive industry which is a national metrication leader.

In the context of other pressing demands within DoD and the Army, metrication is relegated to relatively low priority. There is currently little direct impetus from that quarter, the industrial metrication trend notwithstanding. On the international scene, however, there are indicators that portend a new emphasis on DoD/Army metrication: pronouncements by the President and SecDef focusing U. S. military attention on NATO Europe; adoption of the German 120 mm gun for the new main battle tank; increasing stress on standardization, interoperability, and interchangeability, and on the attendant economic implications of these attributes.

In summary, reasonable and appropriate preliminary metrication steps have been taken by the military. While there is now little direct impetus from U. S. industry for immediate DoD/Army conversion, the progressive metrication of U. S. industry, and the economic and operational implications of a NATO-focused military orientation suggest that metrication will become increasingly significant to DoD and the Army.

CHAPTER 3 NOTES

1. EEC Directives L243/29 (71/354 EEC) dated October 18, 1971 and L262/204 (76/770/EEC) dated July 27, 1976.

2. Statistical Abstract of the United States, 1977, Table No. 1473.

3. Ibid, Table No. 1475.

4. Ibid, Table No. 1473.

5. Memorandum from Richard M. Hurd, Chairman of the Board of ANMC, to ANMC Subscribers, April 20, 1978.

6. ANMC, A Report to the Nation on the Management of Metric Implementation, January 1975, p. 11.

CHAPTER 4

FACETS OF METRIC CONVERSION AND LESSONS LEARNED

4.1 Introduction

In a report of this nature, covering the elements of what has been learned over a year's investigation and a large cross-section of the world's metric experiences, the problem becomes one of distillation. Many experiences have been witnessed by all while some have been peculiar to specific sources. The purpose of this Chapter is to provide a concise summary of foreign and domestic experience in relation to specific aspects of metrication. Emphasis is given to concepts, approaches, experiences and lessons learned which may be directly applicable to Army metrication.

We have organized this chapter into four major categories, plus a summary.

4.2 The Metric Conversion Environment;

4.3 The Philosophy of Conversion;

4.4 The Conversion Process;

4.5 Some Major Details.

Each major category contains a set of sub-categories which provide lessons learned which are of major importance to the U. S. Army metrication plan and organizational needs for plan implementation. The substance of this chapter will cover:

The Metric Conversion Environment

- Voluntary Conversion
- Legal Issues
- The Role of Public Attitudes in Metric Conversion

International Ramifications

U. S. Labor Reaction to Metrication

The U. S. Army Role in National Metrication (Leverage)

The Philosophy of Conversion

Commitment to Metrication

Metrication Benefits, Advantages and Opportunities

Metrication Costs

The Conversion Process

Mode of Conversion

Management and Organization

Coordination of Metrication Activities

Some Major Details

Standards and Specifications

Hybridization

Training

Usage of SI Units, Other Units and Preferred Multiples

Automated Data Processing

The following discussion provides a brief overview of each area.

The Metric Conversion Environment

A series of issues shape the environment into which the Army's metric conversion plans and organization must fit. The issue of the nature of "voluntary" conversion becomes important since a misinterpretation of the nature of voluntary conversion may result in a passive-reactive role by the U. S. Army--at great potential cost. Legal issues have a potential for hastening the voluntary conversion at a more than leisurely pace. Public attitudes have a capacity for causing troublesome conversion and similar problems may be experienced by the Army because of Army personnel who are similarly misinformed or unaware of metrication. This could seriously impede Army conversion plans. International ramifications both by

multinationals, import/export trade balances and NATO standardizations, rationalization, and interoperability are hastening metric conversion. Lack of awareness and non-responsiveness on the part of the Army could serve to penalize the nation. Misunderstanding the kind of and amount of leverage that the U. S. Army enjoys with and on U. S. industry can result in improper or ineffective actions.

The Philosophy of Conversion

The philosophic facets connected with metric conversion focus on three main issues: costs, benefits and commitment. Positive top level statements of commitment backed by top level reviews of metrication progress, are essential to a smooth, least-cost conversion. Many short range or near term costs usually associated with metric conversion have proven to be imagined based on industrial and other nation's experiences. When metrication is planned and coordinated, the advantages and opportunities usually far outweigh associated metrication costs. However, a life-cycle costing perspective is essential.

The Conversion Process

The overriding important issues involving the metric conversion process are related to: how will the conversion be carried out; what management/organization strategy is needed to carry out the conversion most efficiently; and once started how can coordination and communication be structured to enhance the process? The concensus of national (foreign) and U. S. industry experiences with metric conversion is that the mode must be evolutionary. If it is not, then high costs of conversion will result due to forced conversion before the organizational element, the company, the industry or the nation is prepared (planned) to go metric. The organizational structure and managerial strategy must recognize the temporary nature of the metrication task. A business-as-usual attitude and a small dedicated metrication staff, supported by ad hoc groups, are keys to smooth, cost-effective conversion. Effective communication and coordination are keys to a non-disruptive conversion as these

elements ensure integrated planning. Coordination can be used to enhance the conversion process if conducted as a participant activity rather than one of only responding, distributing, investigating when directed to do so.

Some Major Details

The experience gained in the course of this contract are summarized in the Task A (Domestic) and Task B (Foreign) reports, as well as a series of In-Process Reports. The bibliographies associated with those reports contain additional explicit details about the metric conversion process. We believe, however, that the details in this section are most important to successful Army metric conversion efforts. A decision on whether to metricate or on the degree of hard metric vs soft metric is closely tied to availability of appropriate standards and specifications. Army participation in the preparation of ISO, National, Federal and Military metric standards and specifications will ensure maximum utility of national and international standards to Army as well as national needs. Awareness of the status of metric standards and specifications will ease the Army decision process on metrication of Army materiel. Hybridization is the way of life in both old materiel changes, product improvements and in new materiel, and will probably be so for a great many years. While a priori claims have been made that metric training needs will be extensive and costly, foreign, national and U. S. industrial experience do not support these claims. Careful and detailed planning of training needs is essential. Adherence to accepted SI units and preferred multiples is a key to maximizing benefits associated with metrication. The Army should be responsible to U. S. industrial and international practice; not allow deviations from SI and minimize use of other (limited use or obsolescent) units. Finally Automated Data Processing (ADP) is an area where metrication can have significant impacts, especially during the transition period. Careful planning and training will be essential to minimize problems in this area.

Summary

In each discussion, a list of lessons learned concludes the discussion. The Summary of Chapter 4 (Section 4.6) lists each of these lessons learned under its Category and Subcategory heading. This complete list of lessons learned was provided for easy reference by the reader.

The discussions provided here draw heavily upon the Tasks A and B Reports of this study. The reader is referred to these documents for more detail.

4.2 The Metric Conversion Environment

Metrication has a pervasive impact on the nation, and any recommendations with respect to Army metrication planning and implementation must consider the environment in which Army metrication must occur. The purpose of this section is to bring out certain aspects of the environment which are relevant to Army metrication and to highlight major lessons learned from foreign national and U. S. industrial experience which may be applicable to Army planning and policy. The topics discussed in this section include:

1. The nature of "voluntary" conversion;
2. Legal issues with respect to metrication;
3. The role of public attitudes in metrication;
4. International considerations and influences;
5. U. S. labor attitudes toward metrication;
6. The Army's ability to influence industry and the Federal Government.

4.2.1 Voluntary Conversion

On the whole, the foreign approach to metric conversion has been on a "voluntary" basis. In Australia,

> *The Metric Conversion Act 1970 was assented to on 12 June 1970 and states as its object--Section 5--to bring about progressively the use of the metric system of measurement in Australia as the sole system of measurement of physical quantities.*
>
> *The Act provides the Minister with powers on behalf of the Commonwealth, to do such things, make such arrangements and enter into such agreements as he thinks conducive to the attainment of this objective and establishes the Metric Conversion Board...*
>
> *...The Government has made it clear that the metric change will be predominantly a voluntary one, planned and implemented by those who will themselves be affected by it....*[1]

Similarly in South Africa,

> *Our aim throughout the conversion program has been to obtain the voluntary co-operation of people and groups of people in the acceptance of the need for change.*[2]

The U. S. policy towards conversion is to make conversion voluntary also. The Metric Conversion Act of 1975 identified as its purpose:

> *To declare a national policy of coordinating the increasing use of the metric system in the United States, and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.*[3]

Beyond declaring a voluntary conversion, the process of metrication has been pursued in a different manner in each of the countries, depending upon the extent of commitment of the government to metric conversion. While the Australian Metric Conversion Act did not specify a final target date, enabling activities, by the Government in power in 1970 and reaffirmed after each change in Government, in essence established a 10-year conversion goal.

The Metric Conversion Board, using its Directors, Advisory Committees (11) and Sector Committees (84), managed the voluntary conversion by government, industrial and consumer components of Australia's society. Australia's antitrust laws, which are less stringent than U. S. laws, and the presence of a strong government commitment to metrication also facilitated the smooth conversion. The Australian conversion effort, while voluntary in nature, received strong government support and guidance.

In South Africa,

> *Only when we had achieved a virtual consensus in one particular area did we then proceed to introduce regulations to govern the exclusive use of the metric system in that sector.*[2]

> *While the change is "voluntary" in some areas legislation has introduced an element of compulsion, such as through the packing of goods in rounded metric quantities, the prohibition of the importation of instruments not calibrated in appropriate units and, on 1 January 1973, the requirement that trade be in metric units.*[4]

The South African program demonstrates another type of "voluntary" conversion. Consensus mechanisms are used, as they were in Australia, to determine appropriate plans and target dates for conversion. In South Africa, however, these plans are reinforced by regulations.

> *...legislation,...covering other aspects of our conversion program, was only introduced when - in the particular area concerned - there was a compliance of some 90 - 95%, in order to prevent "back-sliding". It was argued that it was not an acceptable situation if one or two persons or companies could by non-compliance, gain a short-term competitive advantage as, by the nature of things, their customers - at that point in time - were more conversant with the old, customary, units.*[2]

The term "voluntary" in the U. S. context is subject to wide interpretation in the current environment. The following excerpts from the March 31, 1978 issue of the <u>Metric Reporter</u> demonstrate two views from members of the U. S. Metric Board.

Thomas Hannigan (labor): "The Board's role is to assure the...government remains neutral; that it does not restrain or promote the use of...metric ...but responds to private initiative."[5]

On the other hand, Adrian Weaver, business and manufacturing representative, envisions a conversion effort more like that of South Africa.

He is certain "specific legislation will be required if and when metric conversion activities...identify legal impediments to continuing plans." However, he does not foresee the passage of legislation in a given area until "producers, distributors, sellers, customers," and others involved in that area reach a voluntary consensus to go metric.[5]

The following 1973 discussion by William Zeiter, Chairman of the Committee on the Metric System in Commercial Transactions, American Bar Association's Section on Corporation, Banking, and Business Law, demonstrates what "voluntary" means in practice.

The bills on their face clearly don't contemplate any mandatory requirements from a legal point of view, such as are contained in the Uniform Time Act. However, these bills all contemplate a system of encouraging people by various techniques to increase their use of metric units of measurement, and some of these techniques may seem quite mandatory to you from a business point of view. For example, your customer may be the Government and it may be that the Government won't buy from you unless you tender in metric units. That metric requirement may seem quite mandatory to you, but to a lawyer you have a free choice of either doing business with the Government on a metric basis or going bankrupt.*

Also, I don't want you to misunderstand and think that this "voluntary" system (from a lawyer's point of view) forecloses certain compulsory features as we go along. Let me give you a few examples. If you went to a drug store and the druggist tried to sell you a half a gill of soft drink, or if you went to a dry-goods store and the dry-goods man tried to sell you three cubits of cloth and if you went to the hardware store and said you wanted some number 14-2 electric wire and the

---

*Paper given before passage of Metric Conversion Act of 1975, refers to the bills leading to this Act.

proprietor tried to sell you a tenth of a rod of electric wire, you would feel that he is in a sense trying to confuse you, or to mislead you, or possibly to deceive you.

In this connection it is important to note that we have doctrines of the law, completely apart from concepts of compulsory measurement standards, which say that it is the job of the Government to police the avenues of trade, and to identify and root out mercantile practices which confuse or mislead the buyer. The experience in other metricating countries whether the expanded use of metric units be voluntary, evolutionary or revolutionary, has been that where you finally get to the situation where almost everyone is thinking and speaking in metric terms, then you have incidentally created a situation where it is possible for a tradesman who continues to deal in the old anachronistic units to get an advantage over his customer. This situation brings into play the general principle that a Government will not permit a tradesman to deceive his customers. The result is that the Government ultimately comes along and formally prohibits the continued use of these confusing, deceptive, anachronistic systems of measure. Therefore, when we think of the present legislative effort as a voluntary conversion program (and it is intended to be legally voluntary now and for the foreseeable future) we must recognize that near the end of the line, the results of the program will so change the nature of the commercial world that other regulatory doctrines will inevitably result in the prohibition of nonmetric units of measure.[6]

U. S. industrial comments support Mr. Zeiter's view of voluntary conversion. John T. Benedict of Chrysler Corporation comments on the voluntary conversion below.

In reference to myth and reality, I would cite the <u>most fundamental myth</u> of all: -- which is the widely held belief (conscious or otherwise) that there is a choice. The essence of this myth is that -- because metrication is voluntary -- individual institutions can decide that they "will or won't" enter into a metric changeover. The <u>reality</u> is that there is no such basic option left. The United States metric trend inexorably will be pervasive. The remaining "choices" really relate to timing, method, and degree of metrication. Once this fact is accepted and grasped, an intellectual commitment occurs -- with the realization that metrication <u>must</u> be undertaken.[7]

The following remarks made by Arthur W. Woelfle of Kraft, Inc., illustrate his organization's concept of a "voluntary" conversion.

> *First -- we believe in the inevitability of the move to metric measurement. Not <u>if</u>, but <u>when</u>, is the question.*
>
> *Second -- we will work towards voluntary conversion, hoping to gain an orderly transition as compared to a mandated conversion with the accompanying danger of the laggards being the victims due to inability to cope in a short time span.*
>
> *Third -- the expected mechanism for voluntary conversion will be through agreements reached in trade association metric meetings.*
>
> *Fourth -- the vehicle, for initiating these metric planning meetings and ensuring their continuation, will be the American National Metric Council*
>
> *Fifth -- finally, the U. S. Metric Board is looked upon as the group to put the final stamp of approval on the voluntary metric plans.*[8]

One sector of U. S. business, the wine and distilled spirits industry, offers a demonstration of the concept of consensus followed by reinforcing regulations. The representatives of the distilled spirits and wine industries in cooperation with the Regulations and Procedures Division of the Bureau of Alcohol, Tobacco and Firearms (ATF) reached a consensus on metric bottle sizes, a phase-in schedule, and target deadline for conversion to metric sizes. The normal procedure for issuing regulations: A notice of proposed rule-making, public comments and public hearings was then followed.[9] After this procedure, the regulation on bottle sizes and a timetable for conversion was promulgated.

> *The phase-in period [for distilled spirits] will be complete by the end of 1979, the deadline set by the U. S. Bureau of Alcohol, Tobacco and Firearms (ATF) for a complete changeover to metric. The new sizes will be 50, 200, 500, and 750 milliliters and 1 and 1.75 liters.*[10]

Currently, consideration is being given to modification of the regulation to permit larger metric sized bottles for wine. This reconsideration was initiated due to comments from both wine-producing trade organizations and from individual consumers.

> *The metric sizes authorized for optional use beginning January 1, 1975--to become mandatory December 31, 1978--range up to 3 liters (101 fluid ounces), which is 21% smaller than 1 gallon (128 fluid ounces).*
>
> *Three-gallon and 4.9-gallon containers are also presently permitted.*
>
> *"The Bureau did not adopt a size larger than 3 liters since at the time we considered the metric standards of fill in 1974, there was almost no interest expressed in sizes larger than 1 gallon," stated an August 22, 1977 Federal Register notice.*
>
> *Industry and consumer comments prompted the bureau to reconsider larger sizes.*[11]

The wine and distilled spirits sections of the U. S. economy are the first groups to convert using a timetable backed by regulation. The approach used here may be the precedent for "voluntary" conversion in other industrial sectors where regulations are applicable.

Lessons Learned

1. Metrication is inevitable. International and some national evidence point to voluntary conversion becoming more binding with passage of time.

2. There are some U. S. sectors where a voluntary consensus has already resulted in regulated changes to metric.

3. Evidence from abroad indicates an acceleration of voluntary metric conversion actions, after national metric boards are established, during the first several years.

Problems for DoD/Army

1. Keeping abreast of the accelerating voluntary metric conversion taking place in the nation.

2. Meaningful input to the action to maximize advantages for DoD/Army.

NOTES TO VOLUNTARY CONVERSION

1. Metric Conversion Board, First Annual Report for Year 1970-71 (Canberra, Australia: Commonwealth Government Printing Office, 1972), pp. 7, 8.

2. Heinrich Prekel, "The Introduction of the International Metric System (SI) in South Africa,"(paper prepared for U. S. Senate, Committee on Rules and Regulations, February 1977).

3. PL 94-168, The Metric Conversion Act of 1975.

4. A. F. A. Harper (Executive Member, Australian Metric Conversion Board), "Conversion: The World Perspective," MCB Newsletter, Vol. 3, No. 8, June 1974.

5. Metric Reporter, March 31, 1978.

6. ANMC, Metrication: Legal and Trade Implications, Metric Conversion Paper #1, 1974.

7. John T. Benedict, "Some Reflections on Metrication Cost Management," (paper presented at the American National Metric Council Conference, Washington, D. C., April 6-7, 1976).

8. Arthur W. Woelfle, "Remarks" (paper presented at the 4th Annual meeting of the American National Metric Council, Atlanta, Georgia, April 3-5, 1978).

9. "Consumer Case Study: An Initial Experience," Metric Reporter, April 15, 1977.

10. "Survey on Distilled Spirits Shows Customer Discontent," Metric Reporter, November 26, 1976, p. 3.

11. "Larger Wine Bottles Proposed," Metric Reporter, September 16, 1977.

4.2.2 Legal Issues in Metrication

The Metric Conversion Act of 1975, Public Law 94-168, was passed:

> *To declare a national policy of coordinating the increasing use of the metric system in the United States, and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.*[1]

The Board is to be composed of seventeen individuals from diverse backgrounds broadly representative of American society. Members on the Board will represent science and engineering, industry, labor, State and local governments, business including small business, construction, commerce, agriculture, standards organizations, education, consumers, and other affected groups.

The U. S. Metric Board is an advisory, coordinating body and has no compulsory powers. Specific functions of the Board are to carry out public education, necessary hearings and publicity to achieve potential benefits as quickly as possible; to encourage the activities of standards organizations; and to encourage retention of U. S. standards in the international arena when U. S. standards are superior.

Conversion to metrics can best be accomplished through a coordinated effort. However, the ability of companies within an industry to coordinate conversion is limited by the U. S. antitrust laws.

> *Legal aspects of metrication will also have to be investigated. In many instances, close cooperation must be maintained between vendors and the corporation, and customers and the corporation. Meetings could be considered violations of the antitrust laws. Should communication and cooperation be required between competitors, some organizations may take the opportunity to charge product allocation or price-fixing.*[2]

In the House hearings on the Metric Conversion Act of 1975, particular note was given to the antitrust implications of coordinated conversion. Hearings were conducted by the Science, Research and Technology Subcommittee of the House Committee on Science and Technology.

The Committee heard expressions of concern from industry associations which felt that participation by its member companies in the metric committees and panels contemplated by the act might expose them to litigation under the antitrust laws. These groups raised the question of whether, by participating in conversations and discussions with other competitive firms in the same industry, such companies might possibly be subject to prosecution under those laws.

It was suggested to the committee that a provision should be included in the bill which would state explicitly that immunity is granted from the antitrust laws for industry activities directed toward informing and advising the Board in the development of individual industry plans. In order to make it clear that activities of this kind are not intended to be subject to antitrust proceedings, the Committee included a section in the bill specifically requiring the Board to bring together industry groups for such purposes under the auspices of the Board.

The Committee further suggests that when such groups, committees and panels are brought together, a representative of the Board be present in some capacity in order to make it entirely clear that the meeting is being held under the auspices of the Board.[3]

In the final bill passed by the House and the Senate, and signed by President Ford, Section 6(2) provides:

Sec. 6. It shall be the function of the Board to devise and carry out a broad program of planning, coordination, and public education, consistent with other national policy and interests, with the aim of implementing the policy set forth in this Act. In carrying out this program, the Board shall--

* * * *

(2) provide for appropriate procedures whereby various groups, under the auspices of the Board, may formulate, and recommend or suggest, to the Board specific programs for coordinating conversion in each industry and segment thereof and specific dimensions and configurations in the metric system and in other measurements for general use. Such programs, dimensions, and configurations shall be consistent with (A) the needs, interests, and capabilities of manufacturers (large and small), suppliers, labor, consumers, educators, and other interested groups, and (B) the national interest...[1]

Unfortunately the nominees to the U. S. Metric Board were just confirmed in March 1978, two years after the Metric Conversion Act was passed. As of this writing (May 1978), the U. S. Metric Board has met only once. Thus while the law provides for anti-trust protection, it has not been available to U. S. companies, making metrication progress slow.

The major coordinated metrication efforts have been accomplished through the American National Metric Council, which the U. S. Metric Board commended in its first official resolution. The working arrangement between ANMC and the U. S. Metric Board appears to be as follows. Sector Plans developed through ANMC's Sector Committees, after approval within ANMC, will be submitted to the U. S. Metric Board for approval. Figure 4-1 illustrates a portion of the Legislation and Regulation and Design and Engineering Tasks from the ANMC Sector Committee for Highway Vehicles. It is part of a draft Sector Plan which will eventually be sent to the USMB for approval. The draft Sector Plan also illustrates the way legislative and regulatory changes will be handled. Because the U. S. Metric Board has officially sanctioned ANMC's activities, it appears that the Board can now extend the anti-trust protection provided for in the law.

State legislation can also act as a barrier to metric conversion. Thus far, however, little has been done in the way of specific metric legislation in the individual states. Activities have been primarily concerned with the establishment of Advisory Councils, Coordinating Committees, the development of metrication plans and policies, metrication publicity, education, and budgetary provisions for metrication education and conversion. One exception to this lack of state legislation is the state of California, where the price of gas may be shown by the liter and a bill on pornography specifies that there may be no sale within 500 meters of schools. The use of metric information is authorized for speed and highway signs and is required on some types of seed packages. Further, legislation for the establishment of an official state metrication conversion council has been proposed.

FIGURE 4-1

ANMC, HIGHWAY VEHICLE SECTOR PROPOSED SECTORS PLAN

SECTOR NO. 2.04	HIGHWAY VEHICLE SECTOR	DATE: 2/22/78	
TASK NUMBER	TASK DESCRIPTION	COMPLETION DATE TARGET	ACTUAL
03	LEGISLATION & REGULATIONS		
0301	Identify measurement-sensitive legislation & regulations needed by the Sector.	Jan. '79	--
0302	Establish conversion priorities.	July '79	--
0303	Submit recommendations to appropriate bodies.	Jan. '80	--
0304	Influence changes to legislation & regulations.		
03041	10% Complete	1979	--
03042	50% Complete	1982	--
03043	95% Complete	1984	--
04	DESIGN & ENGINEERING		
0401	Influence Voluntary Conversion of Product Designs		
04011	10% Complete	--	1977
04012	50% Complete	1983	--
04013	95% Complete	2000	--

Source: ANMC, Engineering Industries Coordinating Committee, February 22, 1978.

In July of 1977, the New York State Legislature approved an amended state Agriculture and Markets Law which states that SI metric is to be the preferred system of measurement for statewide use. Customary measurements are still recognized and either measurement system may be used. New York is the first state to pass such a law. New York is also the first state to develop a range of preferred metric sizes for commodities. The proposed preferred metric sizes have been issued with a call for comments.

In the states of California, Colorado, Louisiana and Oklahoma, there have been modifications to state legislation to include taxes on metric sizes of alcoholic beverages. In the states of California, Oklahoma and Pennsylvania, legislation has been proposed or passed to authorize the use of metric units for weights and measures.

The legal problems in metrication that can be encountered at the state and local levels are demonstrated by the following comment by Arthur W. Woelfle of Kraft, Inc.

> *Many of our products are regulated by state and local laws as to quality, quantity, and even as to the container that may be used. The States need model laws to use as guidelines. Preemptive legislation allowing the use of metric-sized containers, or uniform state laws that do not prohibit interstate commerce, would expedite the transition. This legislation, incidentally, is quite different from that which would impose the conversion. Milk, ice cream and other dairy items are prominent examples which would be affected.*[4]

To facilitate implementation of metrics, the National Conference of Commissioners on Uniform State Laws has founded a committee to draft a metric act, which can be used as a model for all states, to remove legal barriers to metric conversion. The American Bar Association's Metric System and Commercial Transaction Committee is urging that states pass enabling legislation prior to major shifts and initiation of educational programs. State legislation and legal issues are recognized as a problem and mechanisms have been established for resolving some of these issues.

While legal issues such as the ones discussed above may not impact directly on the U. S. Army, they should be considered in assessing industry progress and potentials relating to Army needs.

The discussions above concentrate on broad legal issues which will affect industrial transition but may affect the Army only indirectly. There are several legal areas where Army metrication efforts may be stymied directly. During the course of this study a survey of DARCOM Major Subordinate Commands was conducted. The following is a summary of MSC comments regarding legal barriers to metrication which have a direct effect on the Army.

Procurement laws and regulations may hamper contractor selection or increase cost unreasonably. For example, the Buy American Act could require that metric material or equipment available at a reasonable price in Europe, be purchased at a high price from U. S. vendors. OMB Circular A-76, as another example, could affect the Army's freedom to do work in-house, and (possibly) to prescribe MILSTDs/SPECs for some items. In a third example, cited by TARCOM, a small project which could have gone metric did not do so because the relevant regulations covering introduction of new equipment require that the first system introducing new tools must pay for supplying all potential users with the new tools. In this case, the project budget could not absorb the cost of the tools.

Laws, which specify that subcontracts on large primes issued by the federal government should be equitably distributed geographically, will present problems in some procurements, since metrication in small businesses will not progress uniformly in all sectors. Complaints to Congress about metrication being unfair to small business are already getting attention. Small business spokesmen appear to be making a case for having the government fund their conversion to metric.

SBA (Section 8A) set-asides (and especially set-asides for minority businesses) present a special problem since the firms eligible for competition are, by definition, the least likely to be able to afford the cost of conversion to metric.

Rationalization of available sizes of some products and the provisions of OMB Circular A-76 may combine to freeze out small business from some procurements, since they would no longer be cost competitive. Small businesses now win some MILSPEC contracts essentially by default, since large firms do not find it profitable to tool up for small volume production runs. If A-76 were to be followed, and the Army were to purchase commercially available sizes, large firms could get all Amry business by legitimate low bids.

It is possible that during the U. S. changeover to metric, European firms will be the only possible suppliers of some products. The Army's ability to metricate may be limited, however, by the Buy American Act.

In the Department of Defense Annual Report--Fiscal Year 1979, Secretary Brown discussed the reassignment of management and business policy functions dealing with acquisition to the Office of the Deputy Under Secretary of Defense for Acquisition Policy and the establishment of the Defense Acquisition Regulatory System to provide detailed functional regulations to govern the complete scope of contractual actions.

> *DARS policies and procedures will be published in the Defense Acquisition Regulations and other appropriate Defense policy directives. The Defense Acquisition Regulations will replace the Armed Services Procurement Regulations.*
>
> *The Defense Acquisition Regulatory Council, identified as DARC, has been established to replace the Armed Services Procurement Regulation Committee. The DARC provides a small group of experts to support the development of acquisition policies and procedures.*[5]

It appears that now is the perfect opportunity to revise procurement regulations to incorporate metric considerations since the ASPRs are being replaced. Incorporation of metric consideration would encompass only an incremental cost if done during this process of writing the DARs.

Lessons Learned

1. There are legal barriers to metrication outside of Army control and which will not impact on the Army directly. These legal barriers may inhibit industrial conversion and thus the Army should recognize that the barriers exist.

2. Procurement regulations may need revision if they prohibit or inhibit metric conversion.

3. Incorporation of metric considerations in the DARs appears to be a cost-effective approach to making procurement regulations conducive to metric conversion.

Problems for DoD/Army

1. Ensuring timely revision of procurement regulations.

LEGAL ISSUES NOTES

1. PL 94-168, The Metric Conversion Act of 1975.

2. Larry J. Ouwerkerk, "Metrication Committee Functions," Managing Metrication in Business and Industry (New York: Marcel Dekker, Inc.) 1976.

3. House of Representatives, Committee on Science and Technology, Report No. 94-369, July 17, 1975.

4. Arthur W. Woelfle, Remarks to the American National Metric Council, 4th Annual Planning Forum, Atlanta, Georgia, April 3, 1978.

5. Secretary of Defense, Harold Brown, Department of Defense Annual Report Fiscal 1979.

6. ANMC's Engineering Industries Coordinating Committee, Highway Vehicles Sector 2.04, Proposed Sector Conversion Plan, February 22, 1978.

4.2.3 The Role of Public Attitudes in Metric Conversion

Involving the public in metrication has been given high priority in some countries and low priority in others. Britain, in its metrication plan, does not involve the consumers early in national transition. The low priority given to metrication which involves consumers is demonstrated in the following statement by the Minister of State for Prices and Consumer Protection, in May 1976 (referring to the Weights and Measures Bill intended to give Government power to phase out the use of Imperial units):

> *When the new Bill becomes law, the Government does not intend to proceed with any short, sharp completion of the metric changeover.*
>
> *If consultation is to be meaningful, and the views of the House are to be taken fully into account it would be quite wrong at this stage for the Government to attempt to lay down a rigid timetable for metrication. But its own view is that weighed-out foods, like meat, fish, fruit and vegetables should have the lowest priority for a changeover. Some sizes like the pint of milk or the pint of beer, can, in practice, remain in use indefinitely; the further consultations provided for by the Bill may reveal other examples.*[1]

This policy of not involving the consumer has been followed since the decision to convert in 1965, but there is a debate now on whether the policy is appropriate. The Chairman of the British Metrication Board stated:

> *It is remarkable just how much progress has been made on a voluntary basis but there comes a time when the retail trade urgently demands cut-off dates so that they may make their metric changes together. There comes a time when the consumers demand cut-off dates so that the period when they have to cope with both measurement systems side by side in the shops is kept to a minimum. That time is now.*
>
> *To dither and delay any longer is daft.*[2]

In contrast to the British approach (which has not worked very well), Australia established programs for consumer involvement very early in the transition period. This was accomplished by instituting use of metric units in sports, in weather reporting and in motoring. In

South Africa, a similar emphasis on consumer involvement early in transition was made.

In examining foreign experience, those countries which have had the most successful transitions, have been the ones that involve consumers actively throughout transition. Public attitudes in the U. S. are likely to have a significant effect on how smoothly U. S. metrication proceeds.

In recent years, because the question of conversion to SI in the U. S. has been discussed seriously, a number of public opinion surveys have been conducted to gauge public attitudes and awareness. Gallup Poll results from surveys taken periodically since 1965 indicate that public awareness of the metric system is growing.[3]

While awareness of metrics is growing in the U. S., public opinion favoring the adoption of metrics by the U. S. has not increased. According to a Roper Poll conducted in July 1976[4] and confirmed by the Gallup Poll of January 1977 cited above, only 29% of those who are aware of the system are in favor of its adoption in the U. S. Unfortunately these polls do not measure acceptance of SI, which is much more critical to metrication than advocacy.

Both Gallup and Roper tested interviewees' ability to convert from customary to SI units, by asking several questions relating to mass and distance. Very few could answer the questions correctly and the large majority (80-90%) did not even hazard a guess. Figure 4-2 reproduces part of the results obtained in the 1976 Roper Poll. These results indicate demographic characteristics of those most likely to resist metric conversion and those most likely to accept and promote metric conversion. This data has important implications for industry, retailers, government, the U. S. Metric Board and U. S. Army, in developing conversion plans.

In the last year or so, several Federal agencies have published proposals for certain metric conversion projects and have called for

FIGURE 4-2

Roper Poll Results

	July '76	July '75
Should switch to metric	29%	33%
Should stay with present system	64%	58%
Don't know	7%	9%

	Total	Male	Female
Should switch to metric	29%	37%	22%
Should stay with present system	64%	58%	69%
Don't know	7%	5%	9%

STRONGEST RESISTANCE TO CHANGE

	Total	Rural	Low Income	Blacks	Age Over 60
Stay with present system	64%	79%	79%	74%	72%

STRONGEST SUPPORT

	Total	High Income	Young 18-29
Switch to metric	29%	47%	39%

EDUCATION

	Total	Grade or less	High School	College
Switch to metric	29%	6%	22%	54%

HAVE CHILDREN

	Total	Age 0-13	Age 13-18
Switch to metric	29%	32%	30%

How many kilometers an hour is the equivalent of 50mph?

Correct answer	3%
Wrong answer	17%
Don't know	80%

How many kilograms in a 5-lb bag of sugar?

Correct answer	5%
Wrong answer	6%
Don't know	89%

Source: Metric Reporter, June 24, 1977, p.5.

public comment. The Federal Highway Administration proposed to convert the nation's highway signs to metric. The agency received about 5,000 letters with only 2% favoring conversion. The project was postponed.

In response to the U. S. Department of Agriculture's proposal to convert labels on fish and poultry to metric, about 2000 letters mostly unfavorable to the proposal, were received. The project was shelved.

A third metric project was proposed by the National Weather Service; to begin using the Celsius temperature scale in weather reports. Initial public reaction was unfavorable so the program was postponed. A revised conversion plan, which is to start in June 1979 and allow for a longer transition period than planned initially, was announced in November of 1977.

Unfortunately, many people have taken these postponements and the protest letters as indicative of "public opinion". Many fail to realize that response rate is extremely low and, as is normally the case, those who are against something are much more likely to write letters than those who favor it or those who are not particularly concerned one way or the other. Most Americans probably fall into the latter category. If the U. S. Metric Board successfully attains its objective of creating deeper public awareness and a level of knowledge about SI, future projects are likely to meet with more favorable public reaction.

As the foregoing discussion indicates, while the majority of Americans have heard of the metric system, more than 90% do not have a working knowledge of the system. This lack of knowledge of the system precipitates strong psychological barriers to metric conversion. These psychological barriers will be difficult to overcome and can significantly inhibit national conversion.

As in most societies, there is a strong resistance to change in the U. S. This resistance, coupled with a lack of understanding of the metric system, is due to a strong fear of the unknown and an irrational evaluation of metric conversion. The situation is not enhanced by the myriad of misconceptions about the system and what metric conversion will mean to the individual. Currently there is very few, if any, reliable sources of information about metrics easily available to the consumer. Thus the public's contact with discussions of metric conversion and its implications for the individual is limited to occasional newspaper and magazine articles. Unfortunately some of these articles are just as irrational and uninformed as the readers. The following discussion excerpts some of these articles, as cited in the Metric Reporter.

From a column in the Indianapolis Star by former U. S. Representattive William G. Bray:

> *The housewife will have no end of problems in interpreting her recipes.*

Response in Metric Reporter, September 30, 1977:

> *--In cooking, customary measuring devices can be retained for use with present recipes. Purchase of a second set of measuring cups and spoons will be necessary for use with metric recipes. A few extra dollars for equipment purchase should be the extent of cooking conversion problems.*

From a column by Bill Diehl in the St. Paul Dispatch:

> *...Why do I object--and hope you will too? Because the system being advanced is only half as accurate as the current Fahrenheit method...which is hardly surprising. Anything--new math or fruitless reading lessons--that is less accurate or efficient seems to be to 'their' delight.*
>
> *Consider. At present, we use a temperature system in which 32 degrees is freezing and 212 degrees is boiling. Apparently, these two numbers are simply too much for the illiterates, to whom 'they' cater, to remember. Somehow, it's expected that such dullards will be able to remember two other numbers, zero for freezing and 100 for boiling.*

Under the coming system, called Celsius, that will be the range. Thus, between freezing and boiling in the Celsius method there are 100 degrees. And under the present method, Fahrenheit, there are 180 degrees. In other words, Fahrenheit is twice as accurate as Celsius (or 1.8 times more accurate, to be precise).

Response in Metric Reporter, September 30, 1977:

--Using this logic, the centimeter is 2.54 times more "accurate" than the inch.

Accuracy is a function of the gradations of the units on a measuring device, not of the measurement system. Anything that can be measured in Fahrenheit can be measured just as precisely in Celsius.

These two examples are indicative of the kinds of irrational and illogical reactions to metrics and the type of information upon which public opinion is formed regarding metric conversion. It is imperative that public education be a key part of the national metric conversion effort, as well as of each organization that is converting, whether it be a company, a government agency or a private or public institution.

Incidents, such as the following, should not occur.

U. S. News and World Report carried the recollection of one British carpet salesman who told how a customer backed off from buying a length of carpet after her shopping companion told her to wait until the industry went metric. She would need a lot less carpet then.[5]

Another argument put forth by some against conversion to SI is the loss of cultural heritage. Many individuals view the metric system as "foreign" or "French". This belief, while common, is not true and neither is the belief that our traditional measurement system is American. It is based on the English system of measurement. In addition, the U. S., in 1875, signed the Treaty of the Meter. Since 1893, the international meter and kilogram have been the fundamental standards of length and mass in the U. S. for both customary and metric weights and measures.

Countering the irrational and ill-founded fears of uninformed individuals are the reactions of those in the U. S. who now work daily with the metric system.

> *We visualize metrication as "no big deal"...It is a change to a more efficient measurement language. ...The men who use the system, such as designers, draftsmen, etc., are universal in their evaluation that it is a decided improvement.*[6]

> *Designers who have become used to using the metric system dislike returning to work in the customary system.*[7]

Foreign experience also indicates that consumer/public acceptance of metrics is not all that difficult if a concerted effort is made by the government to keep the public informed. Public exposure to metric units in the grocery store and in other public places facilitate transition. As Mr. Paul C. Boire, Executive Director of the Metric Commission of Canada, aptly stated:

> *The final thought I would like to leave with you is that everyday metric units can best be learned at least cost in this way - by directly experiencing metric units only in everyday practical situations in the market place, on the roads, and at sporting events.*[8]

Irrational reactions to metrication are likely to become less significant as the public/consumer works with metrics in everyday activities such as shopping or driving. However, there are some significant issues which, at least early in transition, will require action. Among these are pricing policies during transition, potential for deception and loss of experience.

The pricing policy problem is particularly difficult in this period of rising prices and costs. Consumers have a real and legitimate concern that as packaging is changed over to rational metric sizes, producers will increase prices but that price increases will be masked by change in size. Coupled with this is a concern that metric conversion will be used as an excuse for price increases which are not justified.

The fear of being deceived by new packaging and prices is a real concern to all sectors of the economy. If consumers feel vulnerable to deceit in packaging and pricing and find shopping confusing and inconvenient, they will not have the confidence to spend and will curtail purchases and spending. A significant decline in consumer spending could have adverse effects throughout all sectors of the economy.

Related to these issues is the concern over the loss of experience. A new measurement system requires individuals to learn to "Think Metric" and to discard the practical knowledge and experience gained over the years in using customary measurements. As individuals gain everyday experience in using metrics, this problem will become less significant. This is illustrated by Australia's experience.

> *In order to assess the attitude of the public after it had been exposed to a metric shopping environment for 12 months, the Board commissioned a survey in December 1976 which was conducted by an independent agency in a suburb of Adelaide where these conditions applied. Before the survey was embarked upon the MCB set down criteria for the figures it would expect and those beyond which it would consider corrective action would need to be attempted.*
>
> *The results follow:*

Survey of Attitudes to Metrication

Topic	*Criteria* *Expected* %	*Criteria* *Concern* %	*Actual Response* %
Metrication as an irritation in shopping	*< 10*	*> 25*	*2*
Problems with the metric system: (a lot or a fair number)	*< 15*	*> 30*	*19*
Too little metric information	*< 50*	*> 70*	*24*
Happiness with the present metric system			
Happy	*> 50*	*< 25*	*64*
Unhappy	*< 30*	*> 55*	*11*

It will be seen that the actual attitudes all fell well away from the regions of concern.

Other conclusions drawn from the survey were equally reassuring. In short these were that exposure to a metric shopping environment was causing concern to very few people, even though many had little understanding of the metric units to which they were exposed -- only 45% knew how many millilitres there were in a litre (but only about 35% knew how many fluid ounces were in a pint!) -- this was not significant for many shoppers who were interested only in buying the package which for reasons of advertisement, size, presentation, price and/or previous experience suited them.[9]

Conclusions

1. Public attitudes toward metrication can strongly affect success of national metric conversion. Early involvement of the public in metrication has been an element of successful foreign conversion.

2. Irrational fears about metrication can be minimized by public education programs and will diminish as experience with metrics increases.

3. Mechanisms will have to be considered to prevent unfair pricing and deceptive practices during transition.

Problems for DoD/Army:

1. Irrational reaction to metric use by DoD/Army personnel will hamper the Services' metric conversion and require an awareness program to overcome such resistance.

2. The Army's awareness program can not await the general public awareness program which will eventually be introduced nationwide by the U. S. Metric Board.

PUBLIC ATTITUDES NOTES

1. John Fraser, quoted in "Consumer Information Bulletin," Department of Prices and Consumer Protection, London, June 1976 as cited in University of Minnesota, Metric Transition in the U. S., December 1976.

2. Lord Orr-Ewing, "Going Metric," Metrication Board, London, May 1976 as cited in University of Minnesota, Metric Transition in the U. S., December 1976.

3. As reported in Metric Reporter, April 29, 1977, p. 4.

4. As reported in Metric Reporter, June 24, 1977, p. 4.

5. Dean Swift, "Metric Conversion and the Consumer," Metric Reporter, April 15, 1977.

6. Letter from Everett L. Baugh of General Motors, in response to FI Survey of U. S. Industry.

7. Letter from L. J. Rankine of IBM, in response to FI Survey of U. S. Industry.

8. Paul C. Boire, "Planning a Metric Canada," (Fourth Annual ANMC Conference, Atlanta, Georgia, April 3, 1978).

9. A. F. A. Harper, "Metric Action Australia," (Fourth Annual ANMC Conference, Atlanta, Georgia, April 3, 1978).

4.2.4 International Considerations and Influences

Primary emphasis in this report has been placed on U. S. metric conversion as a planned process with the U. S. Metric Board eventually acting in some kind of national coordinating role. There are already strong indications that metric conversion may not take place in this way.

The U. S. Metric Board may see its role as essentially a passive one.[1] It is too early for its course of action to be clearly established, however presentation by Dr. Polk, Board Chairman, at Atlanta on April 3, 1978 implied that the Board is treading carefully through the potential national pitfalls. Nevertheless, major industrial conversion is currently taking place with individual companies deciding what is best for their company, with the American National Metric Council (ANMC) acting as a concensus coordinator. A major impetus for U. S. industrial conversion is world trade.

There is also evidence of metric conversion activities in the U. S. Army. Formal metric conversion studies seem to result in token efforts at best. Nevertheless, metric conversion is occurring under the heading of rationalization, standardization, and interoperability (RSI). Secretary of Defense Brown's recent emphasis on standardization with NATO Allies will provide stronger impetus for Army metrication.

This section discusses these international considerations and suggests the inevitability of metric conversion. The point here is that metric conversion will take place regardless of whether there is direction and coordination at national and DoD levels.

International Trade. Although the U. S. is the largest world exporter ($120 billion in 1977), international trade has not been a prime national consideration in the past due to the size of the domestic market. Major increases in the price of oil are now beginning to change that attitude, because the U. S. is running record trade deficits as a result.[2] Increased exports are essential to restoring a reasonable trade balance.

The outlay in dollars when there is a deficit in the trade balance leads to a depreciation of the dollar against other world currencies. In the short term, this is beneficial, for it reduces the cost of exports. In the long term there are other less favorable effects as the price of exports rises and U. S. manufacturers then can raise their prices thus contributing to a continuing and increasing U. S. inflation. The process then becomes cyclical. As a result, exports and export policy will take on greater importance in the future as a means of breaking or slowing the cycle.

To whom, then, does the U. S. export and what requirements must be met? If major trading partners were Borneo, Brunei, Liberia and South Yemen, there would be no problems connected with metric conversion for, along with the United States, these are the only countries not currently on the metric system or actively converting.[3] Figure 3-1 (in Chapter 3) showed that the major countries for U. S. exports are Canada, Japan, Federal Republic of Germany, Mexico and the United Kingdom. These, and the countries from which the U. S. imports, have or are converting to the metric system.

These and other countries are becoming more exigent concerning requirements for SI. A striking example is the European Economic Community Directive (Amendments to 71/354/EEC) which amend the basic 1971 EEC Directive (71/354/EEC) and 23 supplementary directives concerning standardization of units. This latest amendment requires that SI metric units be used in all commercial transactions of the nine member states by April 21, 1978. It is expected that each country will have national law supporting the EEC directive.

The impact can be judged by a statement from Mr. R. E. Monahan, Manager, Engineering Standards, Control Data Corporation at the ANMC Metric Planning Forum in Atlanta on April 4, 1978:

> *If the EEC directive did not exist, CDC would not be at this conference.*

Mr. Mike Thompson, ANMC Program Director for the Consumer Products and Education and Industrial Training Sector Coordinating Committees also points to the EEC directive for its effects on the textile industry due to international trade.

Mr. Peppino N. Vlannes, the Metric Coordinator for NASA also points to the EEC Directive after his European study tour; any new starts in the European aerospace industry will be hard metric from the ground up. Parts and components from the U. S. will have to be designed in metric units to fit. Consequently, even though the U. S. aerospace industry is currently lagging in metric conversion, it will have to convert if it expects to remain competitive.

For further insights into industrial experience and its relation to international trade, Annex A summarizes total shipments by industry in the U. S. in 1975. Imports and exports as a percentage of total shipments are also included in Annex A. These statistics give an indication of the industries where foreign trade (either import or export trade) is particularly important. They also give some indication of where multiple measurement systems may have the largest impact on U. S. industry.

As Annex A indicates, there are several industries where imports constitute a substantial portion (greater than 20%) of the total shipments. Among those industries with the highest proportion of imports are: Primary Metals-Primary Zinc, Textile Machinery, Shoes, Wood Pulp, X-ray and Electro-Medical Equipment and Steel.

Exports constitute a significant portion of shipments in several broad sectors of industry including: Special Industry Machinery, Instruments for Measurement, Analysis and Contracting, elements of the Medical and Dental Instruments and Supplies Industry, the Aerospace Industry, several elements of the Chemicals and Allied Products Industry and the Power Equipment Industry. A number of these products are somewhat measurement sensitive and the majority of these products are being shipped to countries which use SI. As the worldwide use of SI becomes required as part of foreign trade, it is probable that

these particular industries will be more responsive than those less dependent on foreign trade.

Sector analysis of international trade is but one aspect, however. International operations of multinational corporations are another. One percent of all U. S. companies account for approximately 85% of exports, measured in dollars. Components are manufactured in various countries, and 25-50% of U. S. exports, by dollar value are intracompany shipments. With such a large percentage of the market in exports to countries using metric dimensions, it is obviously an advantage to standardize and manufacture in metric units in the U. S. The FI Survey of Industry substantiated the conclusion that most companies with foreign interests are in the vanguard of domestic metric conversion.

When these large companies convert, there is a disproportionate ripple effect through all of their thousands of suppliers.

A recent article on the automobile industry provides supporting detail on these international aspects:

> *With Toyotas, Datsuns and Hondas a common sight on U. S. highways, with Ford taking a hefty share of the burgeoning European market and with Fiat, Volkswagen and Renault casting covetous eyes on the growth economies of the Third World, a major battle is shaping up for dominance of the global auto business...Between 10% and 15% of the manufacturing activity in the major Western nations depends on autos, while an astounding 20% of Japan's manufacturing volume is derived from this one industry...*
>
> *...What is...disturbing, however, is the belief now held by most industry analysts that Detroit is facing a rapidly maturing domestic market and that is real growth opportunities must be found overseas...*
>
> *There is also the problem of market saturation in the U. S. compared with the potential overseas. In the U. S., there are approximately 480 automobiles per 1,000 people compared with about 300 in the European Common Market, 160 in Japan and 25 in Latin America. Competing in those markets and fighting off the inroads imports have made in the U. S. is Detroit's basic challenge in the decade ahead.*

The key to success in the world auto battle will be volume, distribution, service and the standardization of models, so that the parts of a General Motors vehicle manufactured in Brazil will be interchangeable with one produced in Australia. Arvid Jouppi believes that by the early 1980s the real battle will shake down to those companies that can produce 2 million units and penetrate at least to some degree the U. S., European, Latin American and Asia-Pacific markets.

...Ford was the first company to seek cost reductions by pushing for greater commonality of parts among its different models and then concentrating production at just one or two plants to serve many assembly operations. Ford's assembly plants in Britain, Spain and West Germany produce similar cars that can use virtually the same parts.

General Motors is now moving fast...The company is rationalizing design, research and development and manufacturing among its subsidiaries on a worldwide basis and talks of a "world car."[5]

In summary, there are major international economic factors accelerating the trend toward U. S. metric conversion. This is true from the viewpoint of national policy and the policies of individual companies in major sectors of American industry.

Rationalization, Standardization, and Interoperability (RSI). Those same economic factors of economies of scale, potential cost savings through rationalization, and interchangeability which affect American industry also affect the U. S. Army. In addition, political and operational factors exert an additional strong influence not felt by American industry. This means that the U. S. Army may find itself in the forefront of metric conversion without understanding how it got there. It may mean that the U. S. Army will pay cost premiums to convert rapidly in order to achieve goals which transcend more narrow economic considerations. Finally, it means that unless the U. S. Army takes an active role in metric conversion and carries it out on an anticipatory, planned, coordinated basis, recognizing the impact of these considerations, costs will be far greater.

While there is evidence of the impact of the RSI trend in many different activities, a concise summation lies in Chapter IV, "International Activities", The FY 1979 Department of Defense Program for Research, Development, and Acquisition by Dr. William J. Perry. Selected excerpts from this publication follow.

> *Our international programs pursue several important objectives. The primary thrust continues to be enhancement of the military capabilities of the NATO Alliance through closer, in-depth cooperative efforts in armaments development, production and procurement. Major new and unprecedented initiatives for comprehensive NATO defense planning and cooperation were launched by the President during 1977. The initiatives provide the basic impetus and guidance to our international programs in 1978. Our goal is to make increased NATC military effectiveness through armaments equipment rationalization a reality.*
>
> *Standardization and interoperability of military equipment is at the heart of our NATO Rationalization effort.*
>
> *Finally, to maximize the effective return on the collective NATO and other Allied investment in R&D and to accelerate the goals of standardization and interoperability, we are developing programs that trade off the need for technology control against the benefits of cooperation and transfer of critical technology to our Allies; the deciding criteria being strengthened collective security.*
>
> *We are using this policy as an inducement for accelerated progress in interoperability and standardization.*
>
> *Major new initiatives to promote the enhancement of NATO military strength were launched during 1977 and give substance and direction to our international programs for the coming year.*
>
> *These include:*
>
> - *President Carter's initiative at the NATO Summit,*

- *Special Budget Elements Relating to NATO.*

- *New initiatives in Cooperative Armaments Planning and Management.*[6]

For details see Annex G.

Among the systems which are metric to various degrees are: Roland, Copperhead, modular infrared equipment, 155 mm howitzer ammunition, Main Battle Tank and tank guns, Patriot, General Support Rocket System, and bridging for the 1980s. Metrication appears not to be the driving force in making them metric.

To take a specific example, BG Philip Bote, former project manager for gun development of the XM-1 tank states that the decision for the German 120 mm smooth bore gun was made on the basis of the need for a bigger gun. Long range standardization and interoperability were other considerations given the need for a larger gun. While there was a producibility annex of the report recommending the 120 mm gun, metrics were largely ignored.[7] Newspaper reports and other informal communications suggest that the need for reciprocity also played an important role.

The 120 mm gun was selected as a case example because of its currency. It may not be the best, for we have been producing metric dimensioned guns for a long while. Nevertheless, it does make the point that other considerations have been the major factor forcing metric conversion.

<u>Summary</u>. While Army/industry motivations may differ, there is a clear analogy to be drawn between U. S. Army and industrial international operations with respect to metrication. Whereas compatibility of Allied materiel is desired by the U. S. Army, industry seeks, on an international scale, the same compatibility in operation--design, development, production, marketing and service--which it enjoys domestically. Simplification of supply operations is also a common

goal. Metrication offers a rare opportunity to achieve these objectives.

The motivations behind the framing of these goals, and which impel their realization, differ for the Army vis-a-vis industry. Economics, the final arbiter for industry, is supplanted by military readiness for the Army, although economics (e.g., foreign military sales) is also a significant factor. In the international arena, both industry and the Army are subject to political pressures and constraints.

International industrial operations include export and sale of U. S. goods, import and sale of goods produced by foreign subsidiaries, domestic manufacture of goods of foreign design, foreign production to U. S. designs, joint U. S.-foreign development and production programs, and world-wide support and service of products sold. Comparable Army activities include foreign military sales; assimilation of foreign military equipment into the Army inventory; joint U. S.-foreign research, development and production of military systems; and world-wide logistic support of materiel in service.

The above activities are clearly comparable, if not identical. Similar benefits of standardization, interchangeability, interoperability and simplified supply operations incident to metrication would accrue to both industry and the Army.

A common thread through all these activities is communications. Maintenance of a customary or dual measurement language for the interchange of technical data becomes progressively more burdensome. This is particularly true where joint U. S.-foreign production programs are undertaken. The collective economic impact of these activities on industry strongly influences a company's decision to metricate. The same influences are operative with respect to the Army in its relationship with our Allies.

Industry's metrication policies are strongly influenced by its international operations. International considerations affect Army metrication in a similar way. While industry/Army motivations differ in nature and degree, there is a great deal of common ground, and for these reasons industry's international metrication experience appears to be generally applicable to the Army.

At the present time, the major forces behind metric conversion are not related to a planned metric conversion emanating from the U. S. Metric Board providing top level impetus and guidance. The major forces behind metric conversion lie in the international arena. Whether they be trade or RSI interests, metric considerations are almost incidental.

Lessons Learned

1. International factors are a driving force behind U. S. industrial metrication.

2. The Army, due to U. S. industry's conversion, will eventually have to metricate to avoid costly procurement.

3. The Army is subject to pressures in the international arena such as RSI and foreign military sales which will lead to Army metrication.

Problems for DoD/Army

1. Recognition of pacing parameters which affect metrication plans.

2. Keeping pace with U. S. industrial conversion while responding to international demands and influences.

INTERNATIONAL CONSIDERATIONS NOTES

1. Arlen J. Lange, "New U. S. Metric Agency Forces Decision Whether to Push System or to Be Neutral," The Wall Street Journal, March 20, 1978, p.14.

2. "The Reluctant Exporter," Business Week, April 10, 1978, p.54.

3. Arthur W. Woelfle, President and Chief Operating Officer, Kraft, Inc. "Remarks," ANMC Fourth Annual Conference, Atlanta, Georgia, April 3, 1978.

4. Personal communication. See also, P. N. Vlannes, "U. S. Metric Mission to the U. K. and FRG," Scientific and Technical Information Office, NASA, Washington, D. C. 20546, October 1976, NASA-TM-X-74307.

5. Gerald R. Rosen and Jean Ross-Skinner, "The Auto Clash Goes Global," Dunn's Review, April, 1978, pp. 49-53.

6. Department of Defense, William J. Perry, "The FY 1979 Department of Defense Program for Research, Development, and Acquisition," Presented to the 95th Congress, Second Session, 1978.

7. Personal communication.

4.2.5 U. S. Labor Reaction to Metrication

Organized labor is not particularly favorable to metric conversion. In fact, heavy lobbying efforts by labor were significant in moderating the final version of the U. S. Metric Conversion Act of 1975, so that no target dates were included in the bill. The range of opinion is as widespread among labor as it is among the general public. There is a mix of both rational and irrational reaction. There are some legitimate problems which must be considered and solved by labor and industry. Among these are:

- Worker-owned tools. If new tools are required, a decision must be reached on who will cover the cost.
- Retraining. Clearly the who, what, how, where and when must be determined as must the decision on who bears the cost of training.
- Promotion opportunities. There is a fear that some workers may lose their jobs or promotional opportunities as a result of lack of familiarity with SI.
- Loss of experience. Conversion to the metric system makes judgment and experience with the customary system of measurement useless. This may result in greater demands on the employees (and loss of efficiency).

Most of these are short term or one-time problems which are solvable as U. S. industrial experience demonstrates. The following is a proposal by the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO) to deal with the problems of metric conversion.

> *...the (U.S.) Metric Board should provide full reimbursement to workers for newly required metric tools, special unemployment and job placement assistance, relocation allowances and assistance, technical assistance, education and retraining opportunities for workers, including financial assistance for apprenticeship training programs....*[1]

While the fears of U. S. organized labor seem to be intransigent with regard to U. S. metrication, one need only consider the rate of U. S. industry conversion to SI measurements as a positive indication that the expressions of concern are not as serious as indicated. In Australia we find this sentiment expressed about labor's role and labor reaction to metrication.

> *<u>Organized labor:</u> From the outset the Australian Council of Trade Unions (ACTU) has seen metrication as worthy of support and has co-operated in the implementation of our programs to the full. A nominee of the ACTU has been a valued member of the Board since its inception and has provided very useful liaison with the trade union movement.*
>
> *A letter received from the Secretary of the ACTU dated 2 February 1978 states: 'Whilst there was a certain apprehension at the thought of metric conversion, it is a matter of record that at no time during the past seven years in which conversion has progressed to the point of near completion, has there been a dispute brought to the attention of the ACTU related to metric conversion."*[2]

With respect to retraining and loss of experience concerns of labor, the Australian experience indicates:

> *A concomitant aspect is that some factory personnel are required to work alternately on metric and imperial projects. With adequate attention to drawings, tooling and instrumentation, this presents few problems.*[3]
>
> *Conversion is being effected with the active support of organized labor which, while accepting its traditional responsibility of protecting the interests of its members, has not found metrication to give rise to disabilities. Reported loss of expertise or efficiency during or following the metric change has not been an issue and in most cases the need for retraining has been found to be almost trivial. Nor has the replacement of tools been a significant issue; when it has arisen it has been treated as a normal matter for industrial negotiation. A large number of formal employee-employer agreements on terms and conditions of employment have now been rewritten in metric terms. No case of dispute has arisen.*[4]

> *Although unemployment is rising in Australia we are not aware of any worker having lost a job because of metrication.*[5]

Underlying U. S. organized labor's opposition is the inclusion the cost of replacement of personal tools as a bargaining issue. Addition of this area to the negotiations agenda, labor feels, will inhibit the ability to gain other concessions from management.

Clearly, there can be problems brought about by U. S. organized labor but given that it is clearly to the U. S.'s best interest to expand its export markets and that metric products will provide the U. S. with a competitive edge then it is fair to conclude that these problems will be speedily resolved and as a consequence should not adversely impact on U. S. Army metrication actions.

Lessons Learned

1. Legitimate labor concerns about metrication do not present unsolvable problems.

2. Labor attitudes are not likely to inhibit U. S. metrication because of the importance of export markets and the jobs created thereby.

Problem for DoD/Army

1. While labor attitudes are not likely to affect the Army directly, Army contractors may experience problems in this area. The Army should be aware of this.

ORGANIZED LABOR NOTES

1. U. S. Congress, Senate, Committee on Commerce, Metric Conversion Legislation, Hearings, on H.R. 8674, 94th Congress, 1st Session, October 8, 1975. "Statement on Metric Legislation," by Kenneth Peterson, American Federation of Labor and Congress of Industrial Organizations, October 8, 1975, as cited in Robert W. Carmody, Metric Conversion Impact Upon Department of Defense Materiel Acquisition Managers (Ft. Belvoir, Va.: Defense Systems Management School), 1975.

2. A. F. A. Harper, Metric Action Australia (American National Metric Council Fourth Annual Conference, Atlanta, Georgia, April 3, 1978).

3. Australian Metric Conversion Board, 1977.

4. A. F. A. Harper, "Planning and Implementing of Conversion in Australia", Metrication: The Australian Experience, North American Australian Metric Conference, April 1975.

5. Personal communication from Alan Harper of the Australian Metric Conversion Board, 13 February 1978.

4.2.6 Army's Ability to Influence Industry and the Federal Government

With respect to national metrication, DoD and the U. S. Army interact principally with other elements of the Federal government and with U. S. industry. DoD/Army interest in this interaction is to make the metric conversion at minimum cost and disruption of operations. In order to do this it will be vital to establish and maintain effective programs which will assure that DoD/Army positions are considered in the development and execution of industrial and government metrication plans. The following table[1] provides a useful perspective:

	FY 76 Outlays	FY 76 Sales
	(Current Dollars, Billions)	
Total Federal Government	$366.5	-
Department of Defense	88.0	-
U.S. Army	25.0	-
U.S. Manufacturing Industries	-	$1,183

Although military business accounts for a much higher portion of total sales in some industries and companies than the gross average would indicate, it may be seen at a glance that neither DoD nor the Army can exert an absolute influence on U. S. manufacturing industries as a whole, especially considering that approximately half of the military outlays are personnel-related expenses. This is not to say that DoD/Army is not a valued customer of U.S. manufacturing industries. The following extracts make this point.

Caterpillar states:

> *Because the conversion program at Caterpillar is aimed primarily at changing internally (before the customer is involved), the Army or any other customer's action cannot directly aid our conversion program to any significant degree. It could, however, aid indirectly because any efforts to metricate in the U. S., such as government affairs, educational systems, communication systems, etc. can eventually aid Caterpillar.*[2]

FMC states:

> *The Army could facilitate our [Ordnance Engineering Division] transition to SI by beginning to specify metrics in its contracts. A less apathetic attitude by government in general towards metrication would greatly facilitate the total U. S. conversion effort. Conversely an apathetic or negative attitude toward metrication by the Army would make Ordnance's SI transition almost impossible to accomplish.*[3]

Honeywell indicates:

> *...An area for action is to promote the development of practical national standards which will increase availability of metric parts, supplies and services as well as promote commonality between different Army contracts.*[4]

Similarly, IBM notes:

> *...Demands by the Services for complete metric designs, along with similar demands from the private sector, will drastically reduce that time period [during which designs will be hybrid].*[5]

Texas Instruments states:

> *...Although we have been preparing for metric conversion it will take place only when there is an economical reason to do so, such as a customer requirement, and not from anticipation of possible future requirements.*[6]

Thiokol indicates:

> *Your most important question is the ninth, dealing with the actions which could be taken by the Army to facilitate the conversion. Probably the most helpful thing that could occur would be the determination of a date at which all military systems would be procured and delivered in SI units. It would be helpful if the Army campaigned for such a determination.*[7]

Westinghouse states:

> *The most important element of our strategy, in this and other areas, is to be responsive to the needs of our market, and the Army is a valued member of that community.*[8]

Clearly, DoD/Army can influence industrial metrication plans and progress within reasonable limits, but it cannot prevent or force industrial metrication.

As one of the largest of the 11 Federal Departments (in terms of budget allocation, number of personnel, and property holdings), it is not surprising that the weight of DoD interests in the Federal government is considerable. The foregoing table, using outlays as a criterion, also indicates the DoD/Army position with respect to the Federal government. Here again, however, DoD/Army power cannot be absolute, but it can exert a significant influence to help or to hinder any Federal governmant metrication program.

Lessons Learned

1. DoD/Army lacks the economic leverage necessary to either force or prevent industrial conversion to metric.

2. As a valued customer, DoD/Army can influence (help or hinder) industrial metrication.

3. Metrication planning and actions in concert with industry will be in the interest of DoD/Army.

4. DoD/Army can influence (but not force or prevent) metric conversion within the Federal government.

5. Metrication planning and actions in concert with other elements of the Federal government will be in the interest of DoD/Army.

FOOTNOTES

1. Statistical Abstract of the U. S., 1977, Tables 567 and 911.

2. Letter from L. G. Langenstein of Caterpillar, August 29, 1977, in response to FI Survey of U. S. Industry.

3. Letter from M. E. Smith of FMC, September 8, 1977, in response to FI Survey of U. S. Industry.

4. Letter from A. R. Parsons of Honeywell, August 31, 1977, in response to FI Survey of U. S. Industry.

5. Letter from L. J. Rankine of IBM, September 12, 1977, in response to FI Survey of U. S. Industry.

6. Letter from E. J. Tew of Texas Instruments, October 14, 1977, in response to FI Survey of U. S. Industry.

7. Letter from J. T. Gray, Jr. of Thiokol, September 26, 1977, in response to FI Survey of U. S. Industry.

8. Letter from D. H. Fax of Westinghouse, August 19, 1977, in response to FI Survey of U. S. Industry.

4.3 The Philosophy of Conversion

Management attitudes towards conversion and the philosophical approach which the company or organization adopts will have a profound effect on the pace, timing and success of conversion. Critical to an evolutionary, least-cost conversion is a clear, strong commitment from top level management. Without this commitment and direction, metrication is virtually impossible--and a costly transition a a later date is inevitable. The first part of this section discusses the role of commitment in some detail.

Costs of metrication are a controversial issue. Many who have little or no experience with conversion estimate the costs of metrication to be astronomical. However, experience indicates that specific costs associated with metrication are difficult to measure, and are generally small relative to total sales or estimated costs. Metrication benefits, advantages and opportunities may also be difficult to identify and are frequently difficult to measure. Nevertheless, both costs and benefits must be considered in developing metrication plans. These two issues are discussed in this section.

4.3.1 Commitment to Metrication

One of the underlying essential conditions for successful, least cost metric conversion is the presence of the highest (management) level commitment to conversion. This applies to the national and organizational conversion.

The following comment from Dr. Heinrich L. Prekel, Manager of the Metrication Department, South African Bureau of Standards, illustrates the concept.

> *Top management backing of the metrication officer or team is another important ingredient for a successful changeover. Yet it is surprising how often we still find metrication departments and their top teams quite ignorant and disinterested in metrication and what it really entails. Relegating this fundamental change to a clerk with a conversion table and then forgetting about it is inviting trouble. This situation is not exaggerated to make a point; we have come across it often enough. It cannot be overemphasized that many metrication decisions belong in the class of strategic decisions and have to be made right at the top.*[1]

In reviewing U. K. and South African experience, Alan Harper of Australia's Metric Conversion Board noted:

> *In comparing the operations in the U. K. and South Africa the importance of unequivocal government commitment to the change, preferably following an examination of the pros and cons of making it, the early establishment of a planning authority, and the planning and implementation of the change sector by sector on all fronts, seems self-evident if the principles are accepted that the optimum basis for converting a country to the metric system is (a) to aim at progressive conversion to the sole use of the metric system, (b) to convert in as short a period as is commensurate with the dictates of properly coordinated plans formulated in the first place by those who will be directly affected by their implementation, and (c) to convert as appropriate on all fronts simultaneously.*[2]

Regarding Australia's experience, Mr. Harper indicated the key role that a firm government commitment to metrication has played in Australia.

> Q. *Do you believe that it is possible to make the conversion in an orderly manner without some fairly strong national legislation setting a definite timetable?*
>
> A. *I doubt that we could do that. I think that you must have compulsions -- they might only be economic compulsions, they might not be legislative compulsions, but you must have the governments on side.*[3]

At the national level, the U. S. does not yet exhibit a strong commitment to metric conversion. However, the economic factors discussed earlier in this chapter may eventually lead to a strong commitment.

At the organizational level, top management commitment is essential to least cost conversion to metric. Although the following discussion addresses the issue of metric training it is equally applicable to all aspects of metric conversion of an organization.

> *It is imperative that the management of your company be committed to the transition from domestic to metric measurement. Without this commitment, all attempts to develop training programs and/or train personnel in the metric system of measurement will be frustrated. The training manager must be assured of adequate fundings, training personnel, and other resources if he is to do the job required.*[4]

The comments from John T. Benedict of Chrysler Corporation and Larry J. Ouwerkerk of Borg-Wagner Corporation concern:

> *From a management point-of-view, metric conversion is seen as a major, long-term project that will, to some degree, affect every department in the company. In view of metrication's wide scope and long duration, careful planning and effective management are essential.*
>
> *The most valuable aid to smooth and orderly metric transition is the willingness of people, at all levels, to make the change. Clear evidence of top-management commitment and interest is a key factor. A positive, reasonable attitude can engender good response and call forth the resourcefulness that is vital to an economic, well-paced program.*[5]

The decision to convert must have the full support of management. In addition, company directors should take the necessary steps to inform all personnel of metric planning.[6]

In a National Aerospace Standards Committee survey of U.S. aerospace companies, several of the twenty-eight respondents noted that top level management support and direction is required for efficient conversion. The consensus in industry is clear on this point.

The question may arise as to how to recognize the degree of commitment an organization has to metrication.

A company that is definitely committed to metric transition will normally have: (1) announced formally that metric conversion will take place; (2) formed a metrication council or committee to provide direction during the changeover; and (3) appointed a metric coordinator to chair the committee and function as the company's metric spokesman.[4]

IN FI's Survey of U.S. Industry, the companies leading in conversion all exhibited these characteristics. These steps in demonstrating a high level, firm commitment to metrication are applicable to any organization, including the U.S. Army. AR 700-1 provides a framework for establishment commitment but supporting actions have not been taken.

<u>Lessons Learned</u>

1. Highest level commitment in any organization (national, corporate or government) is essential to an orderly, least cost metric conversion.
2. A high level commitment is characterized by:
   a) Formal announcement that metrication will occur.
   b) Formation of a Metric Advisory Group.
   c) Appointment of a Metric Coordinator.
3. Currently the U.S. Army does not exhibit characteristics of high level commitment to metrication.

Problems for the U.S. Army

The U.S. Army has no express commitment to metrication and lack of commitment assures a costly, ineffective conversion. Because of the complexity of the Army, considerable lead time is required for metrication planning. Lack of commitment inplies low priority for metrication planning and implementation tasks. The longer preparation for metrication is delayed, while metrication continues in industry, the less time will be available to do sufficient planning. An unplanned conversion is costly.

COMMITMENT NOTES

1. Heinrich L. Prekel, "Metric Transition Management" in ANMC, Metric Conversion Paper #9, 1976.

2. A. F. A. Harper, "World Perspective in Conversion to the Metric System," A paper given at the North American-Australian Metric Conference, April 1975, in ANMC, Metrication: The Australian Experience.

3. Discussion at North American-Australian Metric Conference, April 1975 reported in ANMC, Metrication: The Australian Experience, p. 25.

4. Dave L. Venton, "Metrication Training" in ANMC, Managing Metrication in Business and Industry, 1976.

5. John T. Benedict, Paper presented to Society of Manufacturing Engineers, Romulus, Michigan, August 21, 1973.

6. Larry J. Ouwerkerk, "Metric Committee Functions" in ANMC, Managing Metrication in Business and Industry, 1976.

4.3.2 Costs

Previous DoD and Army studies have associated major costs with metric conversion, however, foreign and U. S. industry experience do not bear out these pessimistic estimates. This section explores foreign and domestic strategies and experience and highlights essential elements of a least cost approach to metric conversion.

The following discussion, written in 1965, illustrates the ways in which costs can initially be over-estimated and subsequently minimized:

> *I think that many of the published cost estimates for conversion from inch to metric are much too high. They are not padded or distorted, but neither are they adjusted to conversion as it will actually happen. For example, you make a study in your company today to see what it will cost to convert. Each division manager gathers thorough reports on the cost to adjust or replace each item in his plant that measures, weighs, has a gauge or dial, or is a document about these. The aggregate may be fairly accurate for <u>total immediate</u> conversion.*
>
> *But that is not the way conversion will happen. If each of those same division managers were told that conversion would begin today and would continue, say, seven years--and that he had to convert at one-tenth of what he had estimated complete instantaneous conversion would cost--he not only could do it, but could perhaps do better. Ingenuity and imagination--coupled with facing the stockholders--will turn up simple solutions. Replacement will be less than imagined. Some adjustments may actually improve production. Ingenuity and imagination are the motto for success.*
>
> * * * * * * *
>
> *Conversion by the drug houses was almost entirely profit motivated. Use of the metric system cut their costs and standardized the operations for firms with overseas operation. Being simpler and easier to use, the system reduced the possibility of error in an industry where errors can be fatal quite literally, that is.*

The actual experience of conversion in the pharmaceutics industry illustrates the point I made earlier--about how ingenuity works when a company actually implements conversion. One large pharmaceutical company had made a preliminary estimate that it would cost $125,000 to rewrite its formulas in metric terms. Then when the work began and it came down to spending dollars and cents, the effort was simplified. No one sat down and rewrote all of the formulas. Rather, since all formulas were routinely reviewed every two years, the company simply devised a four-year schedule of revision. When the formulas were recast during the normal revision, the extra manhours used to convert them were negligible. Thus, a sizable conversion cost was saved. And, now that the formulas are on the metric system, the cost of rewriting in normal review is much less because of the simplified calculations.

Other expenses which the company had were educating personnel, converting accounts and inventory records, getting suppliers to sell in metric quantities, and changing or replacing weighing and measuring equipment. A pilot study revealed that when employees were properly approached and were thoroughly informed about the whole process, they adapted readily and, on the whole, were enthusiastic.

Savings in inventory control are substantial. As it turns out, in this instance, the company's annual savings are about equal to the total cost of conversion--and this doesn't even take into account the greatly improved safety factor.

Pharmaceutical companies changed because it was advantageous to change. Many other industries will reap similar advantages, although perhaps not as large or as immediate.[1]

The U.S. Metric Study, Interim Report, Department of Defense issued in June 1971, stated that total metrication costs for DoD would exceed $18 billion in 1970 dollars; it was not feasible to compute many of the costs which would force the figure well beyond the $18 billion mark. The Army's share of this expense was estimated to be $4.4 billion. Faced with these estimated costs, the overall tenor of the report was obviously not favorable to metric conversion.

In later years, after the passage of PL 94-168, the Army began to consider metric conversion of specific items of equipment. The most striking examples lie in the studies conducted on helicopters. The aerospace industry is perhaps the most difficult starting point because, according to Mr. Bob Toth of the Aerospace Industry Association, world aerospace standards, including those of the Concorde and other European aircraft, are developed by the U. S. and stated in customary units.

Rather than attempting to review broad trends and considerations, it is perhaps more instructive to consider the Advanced Attack Helicopter (AAH) as a concrete case in order to understand the method used in estimating additional costs of metric conversion. This example is selected because of its apparent impact on the thoughts and attitudes of individuals in DARCOM Headquarters who were queried for their impressions concerning the effects of metric conversion on logistics. The following discussion is based on conversations with Mr. William H. Brabson, Deputy Project Manager of the AAH Project Office and LTC (Ret.) Gary Beaulieu, the author of the study. These conversations were supplemented by the information provided on the briefing slides.

AAH Cost Estimate. The study first points to the lack of metric standards and fasteners in the aerospace industry. Then, independent estimates from Hughes Helicopter and Bell Helicopter forecast a six-month delay and 10% cost increase for a hybrid version. The extent of metric usage in this case is not clear from the available information. Total cost impact in 1977 dollars was estimated to be $35.4 million.

The study indicated that, on the basis of a telephone survey, a majority of respondents estimated that a hard metric version would result in a 6-12 month schedule delay and a cost increase of 15-40% with additional user impacts. Supplementary notes also provided by Mr. Brabson, as well as the conversations, suggest that the underlying strategy was to specify a degree of metrication--hard metric

or maximum hybrid--and estimate costs and schedule delays. On this basis, a metric version of the AAH was not recommended.

The following discussion reflecting foreign and U. S. industry experience will highlight practices and policies regarding metrication costs.

Foreign Experience

In the countries surveyed by FI, the policy has been essentially to let costs lie where they fall. The feeling was that compensation for conversion costs would deter or defeat the goal of making the conversion in the most economical manner. As a rule, only minimal economic aid was made available in specific cases; South Africa, for instance, compensated the conversion of measuring and weighing apparatus used in trade; Australia allowed non-capital tax deductions for conversion costs associated with income-producing property. In Israel, economic support was given for the acquisition of numerically-controlled equipment and precision machinery. The Swedish government allocated some funds for public education campaigns only, and in Finland no costs were covered by the government. Letting the costs of conversion be absorbed by the organization converting, it was felt, was the prime incentive for ensuring that the conversion was accomplished in the most effective and least costly manner.

In general, several categories of conversion costs were identified. These include costs of training (and retraining), maintenance of dual inventories, and replacement and/or modification of equipment. General policy has been for individual companies or organizations to carry out and bear the costs associated with training and dual inventories. Training has been cited as a key element in ensuring a smooth transition with minimal confusion and delay. Costs of training have generally been considered minimal. Dual inventories represent a more significant cost item due to additional space required, additional investment tied up in inventory, and potential for confusion. However, costs have not been considered substantial and training has been used to minimize the problems associated with supplying the correct parts from stock.

The issue of replacement of non-SI equipment both in industry and military is of real concern since costs of machinery, facilities, and large items (such as ships) represent significant amounts of invested capital and are long-lived. The policy pursued has been to replace the older equipment with SI equipment or at the margin, with hybrid SI equipment, but only after careful cost-benefit analysis indicates a replacement is needed to meet new needs or capitalize on new technology.

Non-obsolescent equipment is generally modified with a gradual introduction of SI components replacing worn out or inadequate components. The basis for deciding on replacement vs. modification is cost-effectiveness. Costs in this area are generally viewed to be not excessive with the above described policy in force.

The essence of the comments from both those countries converting from old metric to SI and from Imperial to SI is that although there are real costs associated with conversion, they are less than what were expected in the beginning phases. Rational, cost-effective policies and letting those converting bear the costs have ensured that costs are minimized.

U. S. Industry Experience

In general, the U. S. industrial companies included in the FI Survey or studied through the published literature followed foreign experience. With minor exceptions, such as provision of special tool kits, industry has not established a separate budget for metric conversion. This practice forces cost consciousness and evaluation of costs and benefits at all levels.

> *...a "metrication budget", if established, acts as a "magnet" in attracting costs that otherwise might be covered in regular operating budgets, or reduced by a more resourceful approach to a particular problem.*[2]

Costs are less than originally expected and are absorbed in operating budgets. With little or no prospective reward for extravagance, least cost approaches to conversion have been found. Examples

include conversion of capital equipment in conjunction with normal replacement, and conversion of documents and manuals when they are normally revised. Initiation of the transition by adopting metrics for new designs is a universal and successful policy aimed at minimizing cost. Timing is also important. For example, requiring an industry to produce a metric product before industry is ready is sure to increase cost.

The companies recognize the parts inventory problem and those with the greatest experience are finding control by part number to be most effective. Moreover, by emphasizing new equipment as the key to the metrication process, they hope to minimize dual stockage and related costs.

Original dimensioning on drawings is an aspect of metrication which is common to both industry and the Army. Preferences expressed vary with the company's depth of metric experience. The least preferred scheme is dual dimensioning on the views of a drawing. Next is a conversion table printed on, or appended to, the drawing. The preferred method among the most experienced companies is metric only. J. M. Stockbridge of Buick (which is predominantly metric after a 3-4 year transition) said in a paraphrase:

> *We tried conversion tables for about 3 weeks and gave up for metric-only drawings. Conversion tables are simply a crutch which leads to confusion. I understand that Pontiac retained dual dimensioning a little longer, about 10 months, though.*[3]

As mentioned, however, many companies have not progressed this far. Simplicity, clarity and low cost are arguments which favor the use of conversion tables that, in addition, can be computer printouts pasted on the drawings.

Elements of a Least Cost Strategy

Current DoD and Army metrication estimates and concerns regarding costs do not differ greatly from those made by foreign countries and U. S. industries before a decision to metricate had been taken. The

following discussion provides a development of practices which would eliminate some of these concerns about cost and build on the lessons learned from actual experience. Consideration of these ideas can help develop the type of conceptual framework and orientation toward cost which organizations have come to appreciate as a result of their metrication experiences.

Vigorous overall management of metric conversion will be the most effective way of minimizing cost. A comment from Rockwell International summarizes the close relationship between cost and management:

> *Metrication cost is a highly debatable subject. It depends on many complex factors, the most important of which is how effectively metrication is managed.*[4]

Metrication management is discussed more fully in Section 4.4.2.

Initiate metrication with new designs. By considering only new designs the problems of dual stockage can be reduced. As a simplistic example, a new tank will probably have few interchangeable parts with older models. Parts for both must be stocked as long as both remain in the inventory. It really does not matter whether the new parts are in metric units or not.

General Motors makes the point that introduction of metric units is comparable to the introduction of any other kind of new technology; e.g., alternators replace generators, and they can be dimensioned in metric or customary units as long as interface problems are considered.

As another example, Bell Laboratories has developed a new integrated circuit the size of a staple, but as powerful as the processing brain of a small computer. Interior patterns are designed to metric modules, but the outside lead spacing is based on customary modules to ensure compatibility with printed wiring boards in customary units.[5] This example shows the need for acceptance of hybrid products. It appears that Army metrication cost estimates, which are impressive, derive from consideration of either 100% hard metric

designs or hybrid products with a degree of metric conversion which exceeds current industrial capabilities. Hybridization is treated in more detail in Section 4.5.2.

Further, in connection with emphasis on new equipment, a systems approach (to include tools, parts inventories, and training) should be utilized with new product metrication. The industrial experience which appears most relevant lies with those companies which have introduced completely new systems in metric units. For example, automobile companies are introducing cars whose overall design is in metric units. Industrial practice gives insight into the systems aspects of introduction of new equipment.

Since these examples are so recent, Mr. John T. Benedict, Technical Information Management of the Chrysler Corporation, was interviewed by telephone (April 1978) to determine what Chrysler's recent experience has been in the introduction of the metric dimensioned Horizon and Omni models. He stated that "The change is transparent to metric." In other words, the fact that the new car is dimensioned in metric units is incidental, for change is a way of life in the automotive industry. There is a recognition on everyone's part that metric conversion is simply a part of the job.

In corroboration of the preceding analysis, Benedict stated that the particular tools needed for service are anticipated far ahead of time, and again, the fact that some of them are in metric units is incidental. With one exception, there have been no problems in volume production associated with the use of metric units, only the normal problems associated with a new vehicle; when the production wave neared one plant, however, the management recognized that the plant was not ready to produce in metric units. A catch-up program had to be instituted to be ready on time.

In summary, emphasis on new equipment will minimize complications and costs as far as dual stockage and mixed equipment are concerned. Systems considerations--the usual steps to ensure system completion

in a timely manner, up to specifications, and within budget--are applicable here.

Keep pace with industry. This is perhaps the most important means of minimizing cost. Even if it were desirable, the Army simply does not have the leverage to force a more rapid industrial metric conversion except at exorbitant cost (See Section 4.2.6).

By seeking cost estimates for new equipment which are based on 100% hard metric designs or a degree of hybrid conversion beyond industry's current or planned capability, the Army would, in effect, be underwriting an industrial conversion more rapid than economic circumstances would otherwise justify.

Thus, a least cost strategy implies maintaining an intimate knowledge of where industrial metrication stands. Since industry is converting primarily by product line based on anticipated economic benefits, the Army will have to maintain an awareness of industrial metrication progress and capabilities.

Individual companies face this same problem. From an examination of industrial experience, it becomes apparent that company leaders are taking all logical steps to maintain awareness of metric conversion in their industries, even when they are not taking active steps toward conversion themselves. Much of this activity can be interpreted as a positive and direct means of gaining technical and commercial intelligence. In this way, individual companies can be aware of external conditions which favor conversion and which pinpoint needs in particular areas. They also gain the ability to influence the pace and direction of change instead of merely reacting to it. This is one way of minimizing costs and securing the greatest economic advantages.

Although metrication progress will be uneven within and among industries, and difficult to track, this information will have to be known by the Army when comtemplating the acquisition of a system. Based on this knowledge, procurement documents should not prescribe

a degree of metric content which is beyond the economical capability of industry. As an example, the Army would not try to make an a priori determination of the metric content of a system/product or specify detailed requirements in an RFP. Instead, the Army might simply ask for statement of the metric content to be provided at no additional cost, and make metric content a factor in evaluation. Such a procedure might, however, require revision of current procurement regulations. With the impending supersession of the Armed Services Procurement Regulations by Defense Acquisition Regulations, the timing is propitious (see Section 4.2.2).

Here is one industry comment to that effect from the material provided by Mr. Brabson regarding the Target Acqusition and Designation System for the AAH:

> *Aeronutronic recommends that the level of hybrid conversion that is reasonable from a cost and schedule standpoint should be proposed by the offeror, justified by his analysis of the potential cost, schedule, and reliability impact of conversion on major components.*[6]

The Army must permit industry a degree of flexibility in meeting metric requirements.

<u>Honeywell</u>

> *The major action which the Army could take to facilitate metric transition is to assure that contracts are clear with regard to metric requirements while leaving the contractor as much flexibility as possible in implementation.*[7]

A lack of flexibility is shown by the following comment from a 1967 study on metric conversion of the Maverick missile:

> *With the present set of ground rules this high-risk situation is further amplified by the ground rule that requires the low overhead vendor to convert his machinery, rather than using his ingenuity in manufacturing a part to a metric drawing, which will pass inspection to that metric drawing. Experience shows that there are many diverse ways to accomplish the manufacture. Many different ways are being used in countries currently manufacturing in both systems of units in the same shop.*

The ground rules established for this study preclude the build-to-print vendor from allowing an immigrant machinist from a metric country from working directly from the metric drawing with a conversion table and a set of metric measuring instruments. The rules also prevent him from having shop drawings made in the inch system, for on-the-floor manufacturing, to produce an end item that will pass inspection to the metric drawings. Both of these methods are being used in many different countries in the world during the current world transition from English to metric units.[8]

It is noted that much attention to metric conversion within DoD seems to be concentrated in the aerospace industry. This will probably be one of the slowest sectors to convert because of its relative independence from foreign competition and lack of metric standards. Alternatively, by keeping pace with industry, the Army would be able to determine which industrial sectors were making the greatest progress, and to seek maximum metric appliaction there. Since industry progress is so dynamic, all sectors of interest to the Army must be monitored closely and continuously.

Let costs lie where they fall. As previously discussed, to do otherwise is to subsidize inefficiency, at least as a principle. Foreign and U. S. industrial experience has, however, produced some minor exceptions in the application of the principle.

In some cases, for instance, personal metric hand tools have been supplied to craftsmen without charge. This was done at Lockheed, as a specific example; personal measuring instruments (customary or SI) are not allowed. Metric tool costs are charged to the project, if peculiar to the project; otherwise they are charged to overhead.[9]

By contrast, the current Army practice, where common metric tools are declared items peculiar to (and funded by) a particular project, inhibits rather than fosters metrication as a whole. This is particularly true of small projects in which metric conversion might be the easiest. The point here is that the need to re-define cost accounting categories and responsibilites to accommodate metrication may very well develop. A reallocation of funds may also be indicated as a result of the new definitions.

Metrication cost accounting aspects also enter the picture. It would appear that the Army can track costs most effectively at the time of initial procurement of any item of equipment. Afterwards, it becomes difficult to isolate costs of equipment in inventory, modifications, repairs, etc. Industry has the capability to exercise financial controls of this sort and to determine associated costs of metrication far better than the Army. Experience has shown industry that the effort is not worthwhile. The cost of instituting financial controls is greater than costs incurred in metric conversion. Industry considers metrication costs to be similar to a "noise factor" in total costs.

> *The cost of estimating metrication's overall cost prior to implementing a program is substantial. Once underway, the cost of maintaining an "apparatus" for complete accounting of metrication cost is not justifiable...Instead of installing a complete system for metrication cost accounting some companies feel they control these costs mainly by insisting that there be no separate funding for metrication. Each operating unit is expected to carry out its responsibility (including metrication) within normal budgets and through local ordering of priorities, etc. Obviously, this kind of philosophy cannot be applied 100%. There must be exceptions — where discrete metrication costs are visible; and sometimes they are rather substantial.*
>
> *Also, it should be noted that some companies do partially record metrication costs and report them as such. In some instances, management desires to know some portion of metrication costs and attempts to record them for tax reasons, internal analysis and statistical reporting, and for possible use in product pricing.*[2]

This point again suggests the advisability of emphasizing new procurement as the overall strategy for achieving greatest economies as far as the Army is concerned. Rigorous financial controls elsewhere in the life cycle would be considerably more difficult and costly to introduce and maintain.

DoDD 4120.18 does not prescribe a <u>no cost</u> metrication policy. In addition, interviews with DoD representatives suggested that the intent was to bear a fair share of the cost, in appropriate cases, such as in "areas where defense industry preparedness or defense production readiness may be enhanced."[10] This intent is reenforced by the goal, expressed by Secretary Brown, of strengthening the responsiveness of the industrial base.[11] The question of cost effectiveness is immediately raised: Where can DoD or the Army accept some increased costs or expenditures in order to lower overall acquisition costs?

Standards development is one area of high potential. According to Honeywell:

> *Metric requirements present a new area for potential misunderstanding of contracts...[An] area for action is to promote the development of practical national standards which will increase availability of metric parts, supplies and services as well as promote commonality between different Army contracts. An effort which we consider to be of particular importance is the project by Rockford Arsenal to develop Defense Standard (DS) drawings for commercial grade metric fasteners.*[7]

Honeywell's response raises an important point: Effort by the Army to promote the development of practical national standards will increase the availability of parts and supplies, and this implies a <u>reduction of costs</u>. Standards development is more fully discussed in Section 4.5.1.

The cost picture is not complete without a consideration of offsetting benefits. Metric conversion holds the promise of achieving many economies if pursued vigorously. As an example, several companies point out that digital readout equipment is more efficient and that SI or dual readouts can be obtained at nominal cost. Two companies reported productivity increases of approximately 30%, even when running a production mix of inch and metric items. It is also emphasized that new equipment with this capability is procured under a normal replacement policy, not a special (and expensive) purchase just to "Go Metric." Metrication benefits are treated in Section 4.3.3.

Consider Life Cycle Costs. Most of the measures discussed and opinions presented are based on minimizing foreseeable short term costs. Emphasis on the more immediate and clear cut concerns should not preclude consideration of life cycle costs, however.

The Army maintains equipment over an extremely long life cycle for such purposes as mobilization or military aid to other countries. The best indicator of industrial experience lies in those companies such as Caterpillar which support long lived equipment. Even though major Army equipment may be held in inventory or provided to other nations for longer periods than the 25-30 years envisioned by Caterpillar, the metrication experiences of these companies provide a useful perspective for the Army.

Metrication at Caterpillar[12,13] is proceeding at a measured, practical pace with full appreciation of its effects on construction equipment which must be supported and upgraded throughout its 25-30 year life. Caterpillar will not jeopardize interchangeability and interoperability of its equipment lines, which are manufactured in 14 countries and distributed worldwide. Relying heavily on soft conversion, Caterpillar adopts hard metric standards only where economic advantage or design improvement results.

In Caterpillar's experience, the need to maintain long life equipment and inventories can delay the metrication process. This again points to the need to emphasize new equipment as a focal point for metrication and also to consider the advantages and disadvantages of hybrid equipment (See Section 4.5.2).

During the transition, introduction of hybrid products will be inevitable because of the lack, in some areas, of hard metric standards or metric module materials. Metric product improvements for customary equipment will also produce hybrid equipment in the field. Metrication in this fashion is the least cost approach being pursued by industry. Sperry-Vickers points out, however, that the longer customary standards are prescribed, the sooner new or hybrid systems will become uneconomical to maintain.

Industrial experience suggests the need to minimize dual inventories of parts throughout this period. However, at some point it becomes more expensive to maintain the dual inventory than to replace the equipment entirely. Thus, these costs are related directly to decisions to repair or replace.

In this regard, Mr. Bob Toth of the Aerospace Industry Association points out that the Nike missile entered service in 1958, and replacement parts are still being procured. For this reason, he states that there is a strong emphasis on metric design of new missiles, for failure to change will inevitably shorten service life or greatly increase costs of procuring repair and replacement parts in later years.

Finally, every portent of the future suggests that high inflation rates have become a way of life. In current dollar terms, higher present costs to achieve metric conversion are self-amortizing as they will offset much higher future costs of modernization and repair.

In summary, life cycle costs are much more difficult to determine than initial costs with any degree of accuracy. Nevertheless, they must be considered, and this consideration strongly favors the acceptance of higher initial cost to achieve more rapid metric conversion.

Lessons Learned

1. Manage metrication effectively on the principle of least cost using a systems approach.
2. Initiate metrication with new designs.
3. Recognize the need for hybridization.
4. Monitor industrial metrication progress as a means for minimizing or avoiding costs.
5. Limit metric development and production demands to industrial metric capabilities.
6. Make metric requirements in contracts clear but allow contractors flexibility in meeting them.

7. With few exceptions, let metrication costs lie where they fall.

8. Modify budgets, funds allocation, and procurement procedures as necessary to minimize net Army metrication costs.

9. Capitalize on offsetting benefits wherever practicable; e.g., standards development.

10. Consider life cycle costs.

11. Where urgency is not a factor, replace capital equipment with dual or SI-only capable equipment on normal replacement schedules; similarly, revise publications and manuals when scheduled for normal review.

12. Where cost-effective, consider modification kits to provide dual or SI-only machine capability as an alternative to premature replacement.

Problems for the U.S. Army

The major problem which the U.S. Army will confront is the annual budget cycle. Metrication costs are generally short term and never early in the transition period. Thus some technique will have to be developed for balancing short term costs with long term benefits. Life cycle costs approaches will be significant. In addition, Army policies and procedures, with respect to costs, must be flexible to accomodate various needs. The internal budget procedures must also be reviewed and /or revised to accomodate metrication.

COSTS NOTES

1. Jean W. Nelson, "Cost of Conversion to the Metric System," 14th Annual Meeting, Standards Engineers Society, September 15-17, 1965, Toronto, Canada.

2. John T. Benedict, "The U. S. Automobile Industry in a Metric World," Paper presented at Society of Manufacturing Engineers Meeting (Co-sponsored by ANSI), Romulus, Michigan, August 21, 1973.

3. J. M. Stockbridge, Remarks at Fourth Annual Conference of the ANMC: Metric Planning Forum, Atlanta, Georgia, April 5, 1978.

4. E. B. Ash and R. E. Linse, "An Overview of the Metrication Program at Rockwell International," Provided in response to FI Survey of U. S. Industry.

5. "Compatibility and the Metric Challenge," Metric Reporter, February 17, 1978.

6. Enclosure to letter from W. H. Brabson, Deputy PM, AAH, March 2, 1978.

7. Letter from A. R. Parsons of Honeywell, August 31, 1977, in response to FI Survey of U. S. Industry.

8. Metric Maverick System Study Report, Hughes Aircraft Corporation. September 13, 1967, p. 1-12. AD870902.

9. A. D. Christian, Remarks at Fourth Annual Conference of the ANMC: Metric Planning Forum, Atlanta, Georgia, April 4, 1978.

10. DoD Directive 4120.18.

11. Secretary of Defense, Harold Brown, Department of Defense Annual Report, Fiscal Year 1979.

12. Frank Winters, Statement by Caterpillar Tractor Company before the Committee on Science and Astronautics, U. S. House of Representatives in Metric Conversion in Engineering and Manufacturing (Washington, D. C.: ANMC, 1974).

13. Letter from J. G. Langenstein of Caterpillar, August 29, 1977, in response to FI Survey of U. S. Industry.

4.3.3 Metrication Benefits, Advantages and Opportunities

Metrication promises, in the long run, many advantages which derive fundamentally from the use of a common measurement language, i.e., improved technical communications. This facilitates technology transfer, a benefit which is difficult to quantify, but one which is mentioned repeatedly by U. S. companies as a principal motivator for industrial metric conversion; even outside the manufacturing sphere, improved communication can only be considered a benefit. The following remarks are pertinent:

> *The adoption of the international system of units by the United States will result, for all practical purposes, in a common worldwide measurement system. The good and bad points of either the U. S. customary or SI metric system of measure are relatively unimportant when compared to the advantages of having a common worldwide language of measurement...*[1] (Caterpillar)

> *Honeywell is not yet far enough into the metric system to obtain overall advantages in rationalization or simplification. However, on specific projects involving designing for multinational production, the advantages of a single measurement system and common standards for fastener and material sizes, provided significant cost savings. The ability to readily exchange technology as well as parts and subassemblies across national borders is considered crucial to future business success.*[2] (Honeywell)

> *The most important advantage gained is our main reason for going metric. We now have a common measurement language for communicating engineering information worldwide.*[3] (IBM)

> *We expect that metrication will be an aid in the sale of our products to other countries. A common measurement language should facilitate our communication with manufacturers of equipment and components with which our products are assembled for use in other countries. There has been too little conversion done thus far to provide examples of realization of the expected advantages.*[4] (GE)

> *It [metric conversion] is a change to a more efficient measurement language. It thus becomes somewhat subjective and difficult to measure. The same would be true with our international relationships. The men who use the system, such as designers, draftsmen, etc.,*

are universal in their evaluation that it is a decided improvement.[5] (GM)

Dr. Fred Schmiedeshoff (of the Army Research Office, Research Triangle Park, North Carolina) made the same point directly relevant to the Army on April 6, 1978, in the following paraphrase.

> *The use of the SI measurement system by engineers designing Army materiel should enhance the transfer of technology from the laboratory to hardware as scientific work is reported in SI units. Engineers are cautious and do not like to apply to design things that are unfamiliar to them. The classic example is that of engineers not wanting to use new materials until time proves them out.*

Probably the greatest opportunity offered by metrication is rationalization, the chance to systematically review requirements, standards, and products in order to create new ones which are logically, coherently, and optimally related. Industrial examples abound; the Optimum Metric Fastener System (OMFS), for instance, is replacing 59 inch sizes (and 57 old metric sizes) with 25 new sizes of screw fasteners. As Stanley E. Mallen (Chairman of the ANSI OMFS Study and also the Metrication Planning Officer of the Ford Motor Company) put it:

> *Optimized metric fasteners can be the basis for direct and administrative savings of hundreds of millions of dollars, not just one time, but repeated each and every year.*[6]

Other examples of rationalization efforts follow:

> *We have been able to capitalize on the rationalized sizes of the two metric standards we have adopted. However, we have been selective in the hole sizes we will use from ISO 235. In ISO 235 there are 275 sizes ranging from 0.2 to 40 mm. We have selected 167 sizes from ISO 235 and added 12 sizes larger than 40 mm. Our nonmetric standard listed sizes from #80 to 2.500-inch diameter. Our present standard lists 56 fewer sizes.*[7] (Caterpillar)

> *......In sheet and plate, more than 70 standard inch thicknesses were replaced by less than 45 standard millimeter thicknesses....Caterpillar now uses over*

500 flat bar inch sizes. Designer selection thus far in metric flat bar indicates this can be reduced to less than 200. The round bar conversion is not far enough along to quote numbers but a similar percent reduction is anticipated. Because of the above size reductions, long term savings are anticipated from reduced inventories along with added benefits of simplified inventory control and purchasing functions.[8] (Caterpillar)

For metric fasteners, we have issued a block of part numbers for the most commonly used ranges of sizes and provided this listing to all locations for their use. This will eliminate the proliferation of several part numbers for any specific size, with consequent reduction of inventory space and document maintenance.[3] (IBM)

We do expect to benefit from the opportunity for rationalization, and have this in mind as we develop internal standards and participate in the development of industry standards.[4] (GE)

We can see considerable future advantages in the formulation and adoption of well thought-out standards which can reduce the number of parts, tools and gauges required. These will produce more efficient designs and practices. They will offer an excellent opportunity to "clean house" by eliminating many near-duplicate sizes.[9] (Rockwell)

Rationalization can also result in improved engineering practices, simplification in a variety of ways, and increased efficiency which, in the long term, mean cost reduction on a very significant scale.

H-P is taking advantage of the benefits of SI in rationalizing varieties and sizes; it is finding that significant benefits can be realized by improving engineering (especially mechanical engineering) procedures.[10] (Hewlett-Packard)

Metric tools and scales are much easier to use and read after becoming familiar with them.[3] (IBM)

The use of the Limits and Fits System not only puts a discipline to the selection of shaft and hole fits; but more importantly, it allows the use of the standard limits and fits gauging system with subsequent cost reduction.[3] (IBM)

For equipment conversion, we are using digital readout units. The use of this kind of unit on certain types of machines actually increases operator efficiency fifteen to twenty percent, so that this is actually a return on investment rather than a metric expense.[3] (IBM)

Any measurement system pervades every facet of the society using it, certainly in technical matters, but also in the simplest activities. The customary system of measurement has evolved over the centuries according to no coherent plan with the result that many procedures or ways of doing things become, because of the measurements, very complex. (Try expressing in pints the volume of water contained in a cubical tank 1 foot 2 21/64 inches on a side.) SI is coherent, making an analogous calculation in metric utterly simple. There are, moreover, less obvious procedures predicated on the use of customary units, procedures which might be modified to advantage with the adoption of SI. One approach to metrication is to merely substitute SI for inch-pound units with no change in method, or without investigating possibilities for method simplification or improvement which the use of metrics may offer. Unless such investigations are conducted, the benefits of metrication may not even be recognized, let alone realized.

Benefits will not come automatically. We must be alert to seek them out and aggressive in pursuing them. In brief, we must be masters of change, not servants.[11]

Canadian experience provides an illustration that metrication benefits can be derived through the use of new procedures made possible by conversion.

As the grain moved through the elevator systems from producer to consumer, grain was weighed in pounds to determine its quantity, but each transaction was also recorded in bushels. Each time this happeneed a conversion calculation had to be made because the unit of weight was pounds but the unit of payment was bushels (which are arbitrary units of so many pounds depending on the grain involved.) Calculations were required approximately 16 times from the arrival of the grain at the country elevator until it reached its final destination. The total number of extra

calculations annually throughout the industry was approximately 15 million. The extra cost of this has been estimated at $1,000,000....The industry decided to change from bushels to tonnes in order to avoid the extra cost of these calculations.[12]

In conjunction with metrication of garment sizes, Dean Swift (President, Sears, Roebuck and Company) recognizes the unique opportunity for the industry to revise decades-old human anthropomorphic models.

In this area, conversion is really a consumer movement. It's naturally expensive to have merchandise returned because it doesn't fit and those costs are passed on to the consumer. With more realistic size measurements, we can do a better job of serving our customers.[13]

Texas Instruments, voicing a widely-held view, makes the following important point concerning metrication benefits and the length of the conversion period:

Although the SI Metric System has several advantages, such as direct relations between units of measure, based on units of ten and uniformity of international trade, TI can capitalize on those advantages only after conversion is fully implemented. The longer a transition period, whereby conversion charts are necessary on drawing and other documents and machine tools are customary or dual, the longer before advantages will be realized.[14]

<u>Lessons Learned</u>

1. Metric benefits are generally long term rather than immediate.

2. Some metrication benefits are intrinsic, such as simpler calculations and improved communication.

3. Metrication offers a rare opportunity to evaluate current practices, create rational new ones, and abandon obsolete methods.

4. Recognition and exploitation of opportunities afforded by metrication is prerequisite to realizing the benefits, particularly tangible benefits, of the conversion.

Problems for the U. S. Army

1. To counter the unfavorable light in which metrication has been cast the Army needs to establish an information media that creates awareness of metric conversion benefits, advantages and opportunities and balances these against Army metric conversion problems. This information should be widely communicated.

2. Recognition that benefits, advantages or opportunities gained in one element of the Army may have application to other elements. Establishing a method to ensure timely information interchange is crucial to maximizing the benefits from metric conversion.

NOTES

1. Frank Winters, Statement by Caterpillar Tractor Company before the Committee on Science and Astronautics, U. S. House of Representatives, in Metric Conversion in Engineering and Manufacturing (Washington, D. C.: ANMC, 1974).

2. Letter from A. R. Parsons of Honeywell, August 31, 1977, in response to FI Survey of U. S. Industry.

3. Letter from L. J. Rankine of IBM, September 12, 1977, in response to FI Survey of U. S. Industry.

4. Letter from W. R. Kruesi of GE, August 22, 1977, in response to FI Survey of U. S. Industry.

5. Letter from E. L. Baugh of GM, August 26, 1977, in response to FI Survey of U. S. Industry.

6. S. E. Mallen, "Metric Fastener Overview," Paper given at International Automotive Engineering Congress and Exposition, Detroit, February 28 - March 4, 1977.

7. Letter from J. G. Langenstein of Caterpillar, August 29, 1977, in response to FI Survey of U. S. Industry.

8. Robert B. Liss (Chairman, Caterpillar Corporate Metric Materials Committee) "Materials Metrication at Caterpillar," Metric Reporter, January 6, 1978.

9. Letter from E. G. Ash of Rockwell International, September 12, 1977, in response to FI Survey of U. S. Industry.

10. Telephone conversation with John Bogren, Hewlett-Packard Company, October 3, 1977.

11. John T. Benedict, "The U. S. Automobile Industry in a Metric World," Paper presented at Society of Manufacturing Engineers (Co-sponsored by ANSI), Romulus, Michigan, 1973.

12. Paul C. Boire (Executive Director, Metric Commission Canada), "Planning a Metric Canada," ANMC Metric Planning Forum, Atlanta, Georgia, April 3, 1978.

13. Dean Swift, "Centimeter Sizing Should Eliminate Faulty Fit," Metric Reporter, August 19, 1977.

14. Letter from E. J. Tew of Texas Instruments, October 14, 1977, in response to FI Survey of U. S. Industry.

4.4 The Conversion Process

This section deals with some of the critical operational aspects of metrication. The first subsection, "Mode of Conversion" discusses the advantages of an evolutionary, planned conversion and explores other options. The second subsection deals with the major aspects of managing and organizing conversion activities. Generally, the role of management is explored and the types of organizational approaches used by foreign nations and U. S. companies are summarized.

Coordination and communications are very important to a successful metric conversion. The third subsection explores ways of assuring coordination and the importance of the Army keeping pace with U. S. industry.

4.4.1 Mode of Conversion

The mode of conversion means the way in which the metric transition takes place. Conceptually, the mode may range from revolutionary to evolutionary. A revolutionary transition implies an abrupt changeover to the usage of SI measurements. This approach has not been tried nationally in any case known to FI. High costs (of rendering usable inch equipment obsolete, for instance) and technological infeasibility (e.g., unavailability of suitable standards and basic components and materials) have precluded abrupt changeovers by any of the sources studied by Forecasting International, Ltd. Transition by fiat, with a relatively short, immutable target date for complete conversion, suffers some of the same shortcomings; costs become prohibitive, as may be inferred from the U. S. Metric Study of 1970.

The evolutionary conversion mode has been universally adopted by nations and companies with successful transition records. Indicative of an evolutionary approach is the pattern followed by Australia.

> *Broadly, 1971 has been the period of planning and coordination for all the main areas in both public and private activity; 1972 is seen as a year of increasing public awareness and involvement, 1973-74-75 as the years of major implementation; while by 1976 it is expected that 70 per cent to 80 per cent of the nation's activity will have been converted to the metric system.*[1]

The essence of U. S. industrial experience is captured by these statements.

> *Recognizing that metric changeover is necessary, the objective is to perform it over a number of years, on a least-cost evolutionary basis.*[2] (Chrysler)

> *In November 1971 we began our conversion by making new drawings for new models in metric units. We continued to make new drawings for improvements to existing models in non-metric units. In 1976.... design section aware that they were losing ground. In first quarter of 1977 we began to make all drawings in metric units.*[3] (Caterpillar)

[Corporate policy is to] convert as soon as possible without causing severe disruption of production or incurring unnecessary costs.[3] (Caterpillar)

The decision of when to convert is left up to the individual division. Some divisions may be substantially metric in as little as 5 years while others may still be 15 or 20 years away.[4] (FMC)

At late July and early August 1977 meetings of the General Motors Board of Directors and corporate executives, Mr. Richard L. Terrell, Vice Chairman of General Motors, observed, "General Motors is in the midst of an ongoing conversion to the metric system - a conversion which has been paced, and accelerated, by our unprecedented redesign program. Chevette was our first U. S. metric car, the 1977 B/C redesign was metric, and so is the 1978 midsize program - all in keeping with our plan of going metric as new parts and new designs are released.

In fact, with the introduction of our new mid-size cars, we will be past the halfway mark - we'll be more metric than inches and pounds. And by 1982 or so, the conversion will be virtually complete. Meanwhile, it is going very smoothly and essentially at little or no cost.[5] (GM)

It shall be the company position that a gradual and careful transition toward full metric capability be pursued in its design, manufacture, and marketing of products in the future. This transitional period will be a planned and coordinated one of approximately ten years, where a "Metrication Plan", herein contained, provides the guidelines and basic considerations to be made.[6] (Honeywell)

These evolutionary approaches have proved to be the least costly and, other things being equal, the most effective.

Another facet of the conversion mode (one of the "other things" mentioned above) is the philosophy of prosecuting the conversion on all fronts at once. Since any measurement system pervades the society, it is reasoned that metrication in one industry must affect others on which it depends or which it supports. The successful Australian and South African experiences illustrate the efficacy of the all-fronts-at-once approach; the United Kingdom, on the other hand, chose to metricate industry-by-industry. This decision

explains, at least partially, the metrication difficulties which have developed in the United Kingdom. Conversion on all fronts at once does not imply that each industry or sector will progress at the same rate, but rather than each will progress at a rate governed by the particular circumstances relevant to that industry or sector.

Illustrative of U. S. industry viewpoints are these thoughts expressed to Forecasting International, Ltd. in our industrial survey and in published literature.

> *Rather than set a schedule, we began to convert at as fast a pace as was feasible, consistent with our ability to handle the change, and keeping the rate of progress commensurate with the cost.*[2]
>
> *...once inevitability of metrication is accepted, one then can progress to an understanding that the cost-versus-benefit results can be improved substantially by planning for the change, rather than by just letting it happen.*[2] (Chrysler)
>
> *The Corporation announced internally in March 1972, that SI (ISO 1000) was to be the preferred measurement system for new product designs and the leading disciplines, processes, tools and equipment supporting those designs. This would include the use of SI metric in all pertinent documentation and communication in Engineering, Manufacturing and Field Engineering.*
>
> *We are presently five years into our changeover schedule and our major target dates have been passed. Our objective now is to continue to increase the use of SI and the ISO standards until 1982, when they will become the predominant system in IBM.*[7]
>
> *Time the conversion program to be in step with the division's industry. ...Involve all departments in the metric decision-making process. Avoid unilateral action.*[4] (FMC)
>
> *Set priorities and needs during the transition; these can differ by company and by divisions within a company...*[6] (Honeywell)

Indicative of South African and U. K. experiences and thoughts on attacking metrication on a broad front and simultaneously is this expression.

> *In comparing the operations in U.K. and South Africa the importance of unequivocal government commitment to the change, preferably following an examination of the pros and cons of making it, the early establishment of a planning authority and the planning and implementation of the change sector by sector on all fronts, seems self-evident if the principles are accepted that the optimum basis for converting a country to the metric system is (a) to aim at progressive conversion to the sole use of the metric system, (b) to convert in as short a period as is commensurate with the dictates of properly co-ordinated plans formulated in the first place by those who will be directly affected by their implementation and (c) to convert as appropriate on all fronts simultaneously.*[8]

Guiding the start of overall planning for Australia's metric conversion are these statements.

> *Conversion is expected to proceed simultaneously throughout many different sectors of the community.*[1]

> *Each sector is expected to develop the program appropriate to its activities and circumstances, but in doing so account must be taken of related activities in other sectors. The structure of Sector and Advisory Committees established by the Board is intended to facilitate the development of such programs and their integration into an overall conversion program.*[1]

Understanding of the Australian position can be gained from this statement pertaining to the Engineering Industry Sectors.

> *Each of these sectors covers a very wide span and careful planning is proceeding to ensure that metric materials will be available when required and conversely that when commencement of production of metric materials is planned the necessary demand exists, to minimize the burden of dual stocking during the periods of change. It is proposed to take the opportunity wherever practicable to rationalize product sizes so as to eliminate uneconomic diversity in production.*[1]

Internal to a given Australian sector, 'M' days were established. The reason is aptly expressed by Hans Milton, former member of the Australian MCB's Building and Construction Advisory Committee in an interview reported in the November 26, 1976 issue of the ANMC Metric Reporter.

> *MILTON: Yes, it is most desirable as a focus for conversion activity. If there is an M-day as a reference point one can relate every activity, chronologically or sequentially, to this particular target point in time. What we did in the Australian construction industry was analyze the real-life processes in the industry. We felt it was most desirable to designate as M-day the point in time when we wanted real demand for products to coincide with real production of products. Producers will not produce metric products unless they're guaranteed a demand. And designers cannot guarantee demand--they can only forecast demand. But an M-day imposes a discipline on both parties. If a design project is scheduled to be built after the M-day it should be detailed in metric units. Otherwise the client may get a prematurely obsolescent building. In turn, the M-day provides the producer with a degree of assurance that his metric products will sell and that he won't be forced to carry dual inventories for an extended period--if at all. Without an M-day there is little incentive to change to metric "until all the others have done so"--and all the others will also be waiting.*

The substantive gains realized by the Australian conversion activities following these management strategies is shown by this statement of the state of conversion as of 30 June 1977.

> *Australia's conversion, planned and implemented by representative committees of national leaders, organizations and Government, is now well on the road to completion. The emphasis has shifted from "what has to be done" to "what remains to be done" and accordingly attention is now mainly concentrated on:*
>
> - *bringing the few major incomplete programs to fruition;*

- *searching out and resolving those isolated situations where metrication has not occurred or is encountering difficulties;*

- *tidying up aspects ancillary to the main stream of metrication such as the use of non-metric units, both in general and in particular applications, e.g. in legislation, industrial awards and measuring devices; and*

- *assessing and analyzing the success of the conversion programs in specific industries and as they affect the public as a whole, with a view to determining how complete conversion is and whether the Board's tenet of education by involvement and exposure to a metric environment is adequate or needs supplementing.*[9]

Timetables, a third facet of the conversion mode, may be defined and used in various ways. Establishment, early in the transition, of an unchangeable deadline for complete conversion, as discussed above, is not viable.

Timetables marking significant conversion milestones have, however, been successfully used for planning and management purposes, provided they are realistic and flexible. Realistic timetables have been achievable only by involving in their establishment, all entities which will be affected by the timetables. Flexible timetables are those which, for good and sufficient reason, may be changed as conversion progresses. In other words, timetables predicated on the best judgment available may still prove infeasible (as a result of uncontrollable events, for instance), hence a means of adjustment for cause must be incorporated.

An overall picture of the total lack of rigidity in U. S. metric conversion timetables can be gained by review of the U. S. industry companies that Forecasting International, Ltd. surveyed during 1977 as to their metrication activities. Figure 4-3 shows the results. Eight of the 26 companies that we surveyed had bracketed

their estimate date of when they expect to be substantially converted. Seven have indicated fairly lengthy transition periods with no real completion date, point or bracketed, indicated. Eleven have not announced metric conversion plans except to respond to customer needs.

A sampling of U. S. industry remarks made to various meetings, surveys and government reviews of metrication yields some insight into why flexibility is essential to good management of a metric conversion program.

> *Axiomatic to effective planning, is the setting of priorities and needs during the transitional period. Product or internal needs are first, followed by the second need or obligation to fit into the U. S. national scene. Obviously, one company is different from another; even divisions of a company entail different product schemes and situations. However, some optimized guidelines can be set which can be used effectively as a point of departure.*[6] (Honeywell)

> *We are presently five years into our changeover schedule and our major target dates have been passed. Our objective now is to continue to increase the use of SI and the ISO standards until 1982, when they will become the predominant system in IBM. This means that although our designs will be predominantly metric in those areas which we control, the commodities, which we must procure for our designs from those segments of U. S. business which have not changed to metric, will continue to be customarily dimensioned. Examples of these commodities are electric and electronic components, motors, switches, etc. Therefore, for many years, until the U. S. is completely converted, we will have a hybrid metric/inch product.*[7] (IBM)

> *With respect to the matter of going "metric," it depends very much, as we see it, upon the individual company's situation in the economy, and in the matter of how much material and how many components*

in a year that company is likely to use. A large manufacturer who orders tremendous amounts of material can get anything he desires by going directly to the mills. Also with respect to standard parts, if he goes directly to a vendor and says, "I want so many millions of such-and-such," chances are the vendor will modify his standard components so as to meet that need. We at Addressograph-Multigraph, are not in that position, because our production rates are not that great. What we have had to do is to take a position that we cannot be among the "stragglers". We must be somewhere in the middle, so that we coordinate our adoption of metric, with the availability of metric standard components and metric standardized materials in the economy and in the marketplace.[10]

The spectrum of milestone target dates of U. S. industry is illustrated in Figure 4-3. Figures 4-4 through 4-7 show flexible metric conversion scheduling is the adopted approach. Very few of the major events are scheduled to occur on any single date; rather a target period is generally identified.

Other U. S. companies surveyed indicated a variety of flexible schedules for metric conversion.

The decision of when to convert is left up to the individual division. Some divisions may be substantially metric in as little as 5 years while others may still be 15 or 20 years away.[4] (FMC)

Rockwell International has been active in preparing for metric adoption since 1967, both internally and externally with the pacing factors being cost effectiveness and customer requirements.... Use general corporate policies (not edicts) and specific division profit center implementation...[11]

We have looked at the benefits and problems of metrication and have concluded that no one approach nor any one specific timing would be appropriate for all of our businesses. We have, as a consequence, left the decision on conversion in our decentralized operations to the individual division management.[12] (Brunswick)

FIGURE 4-3

GENERAL METRICATION HISTORIES AND PROJECTIONS

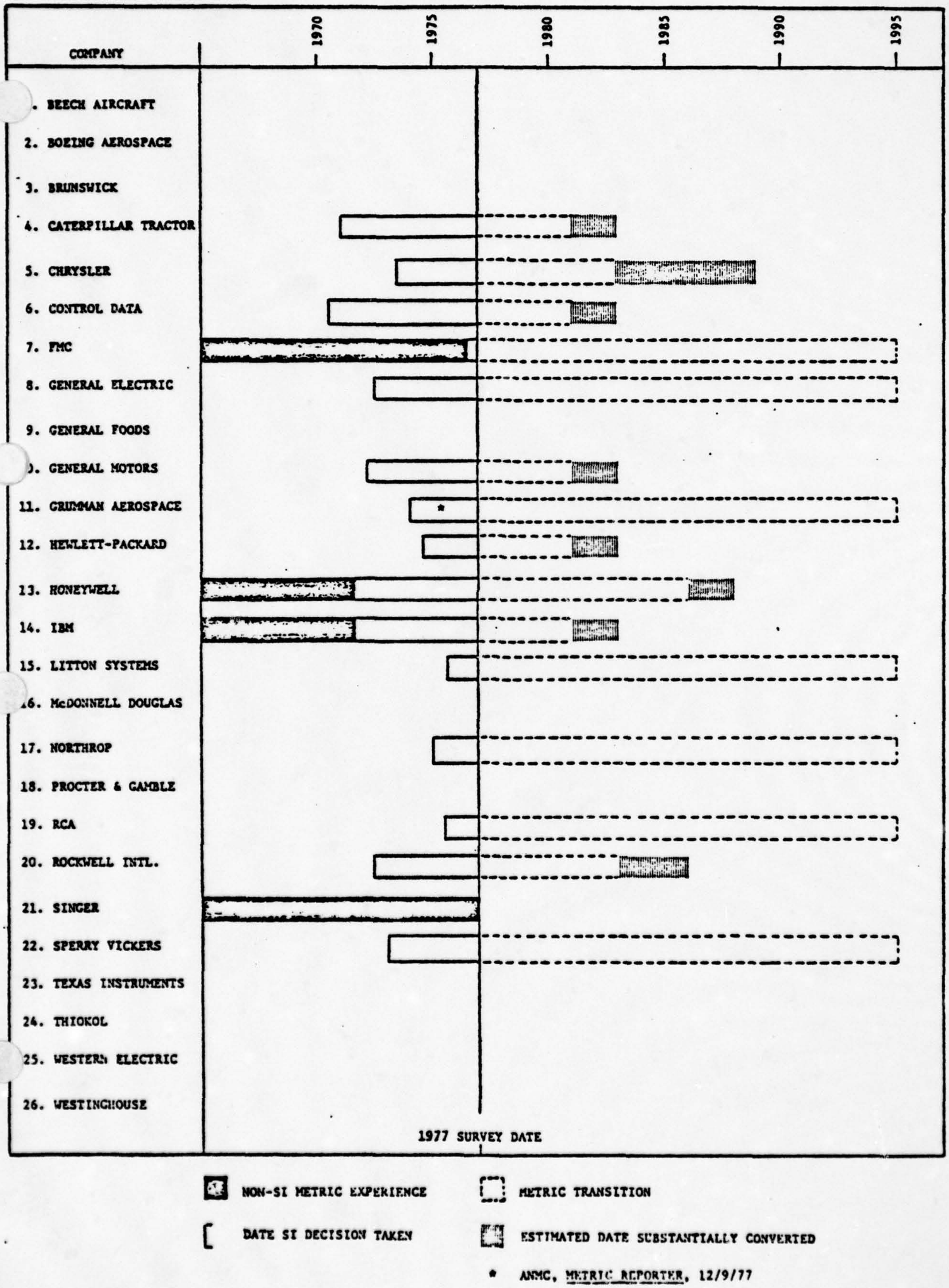


FIGURE 4-4

METRICATION HISTORY AND PLANS

Caterpillar and Chrysler

Caterpillar Tractor Company

1982 Approximate conversion completion date

1979 Hard SI material thicknesses specified in most drawings

1977 All new drawings to be SI

1976 All standards soft converted; issued hard SI standards regarding drill sizes and mill stock sizes

11/71 Metrication Policy Decision - drawings for new products only to be SI. Start soft converting standards

Chrysler Corporation

1990–1985 Complete metric transition

1983–1980 Period of peak dual measurement usage

1977 Production of first metric cars (Plymouth Horizon, Dodge Omni)

1976 Collaboration with Army regarding metric fasteners for XM-1 Tank

11/73 Metrication Policy Decision

1976–1973 Preparation for Metrication

1973–1971 Metrication Planning

1965 Started converting foreign plants in concert with national metrication programs

FIGURE 4-5

METRICATION HISTORY AND PLANS

Control Data and General Motors

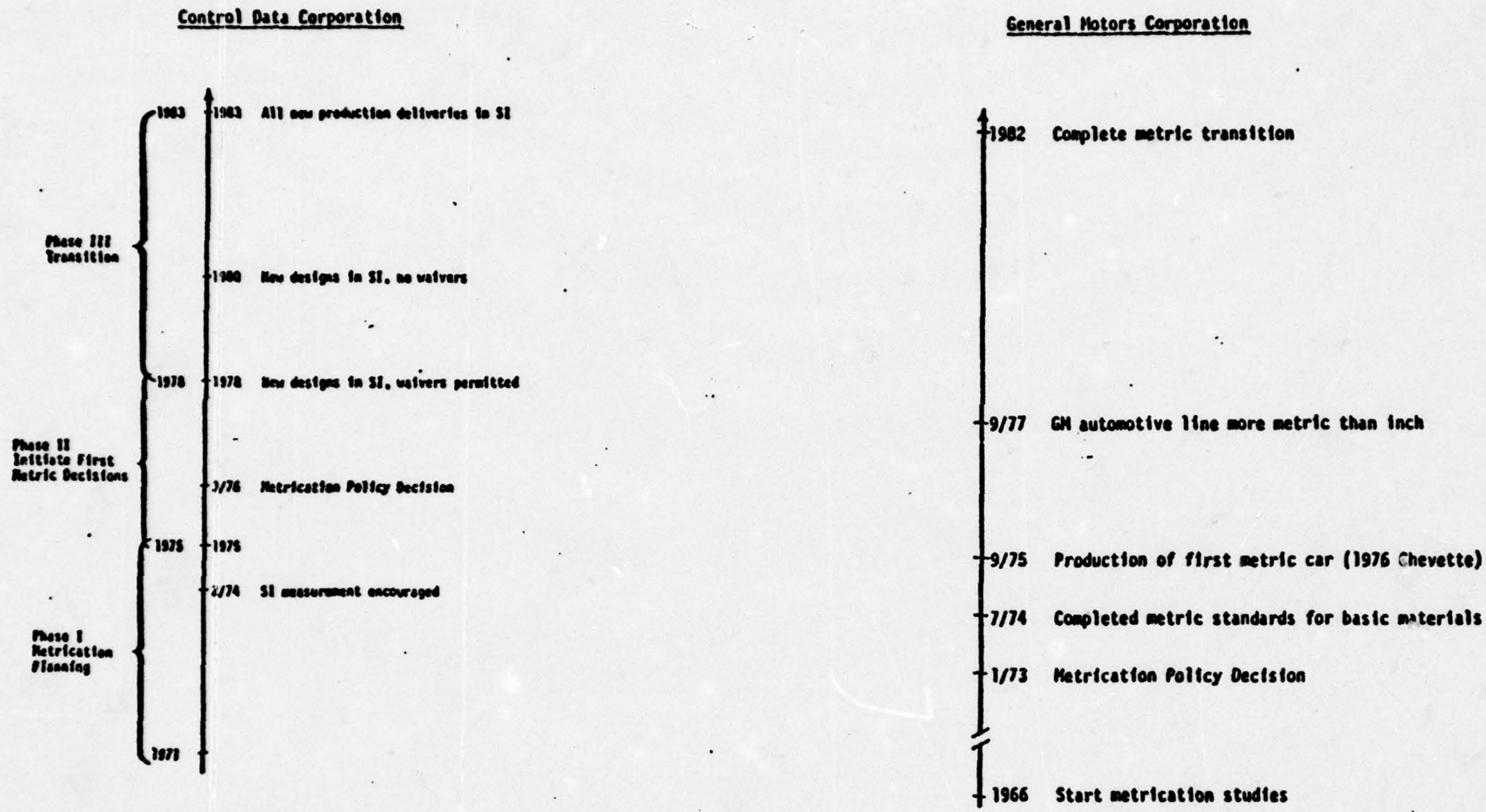


FIGURE 4-6

METRICATION HISTORY AND PLANS

Honeywell and IBM

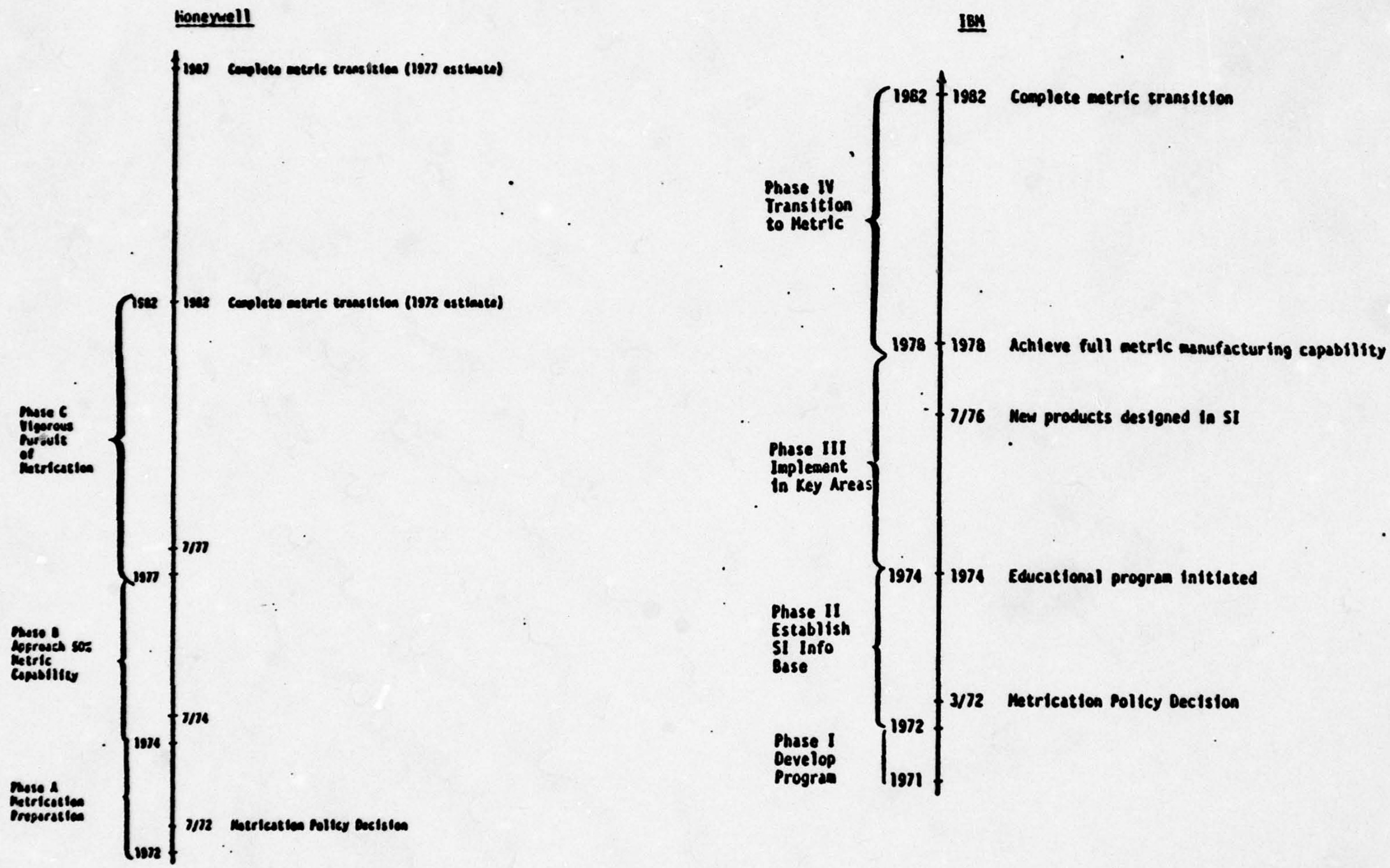


FIGURE 4-7

METRICATION HISTORY AND PLANS

Sperry Vickers

<u>Sperry-Vickers</u>

1975 — Manufactured first hard SI product
All new designs (except aerospace) in hard SI

9/73 — Metrication Policy Decision

1971 — Initiated metrication study

It is not anticipated that the company will decide to convert its overall operations until such time that it is economically practical or when a majority of projects or products are made to metric dimensions.[13]

Conversion undoubtedly will not be made until there is an economic advantage for the Company to do so. Our projections are that it will take at least 20 years for the conversion to be total in the aircraft industry.[14]

Late in the transition, when approximately 95% converted, closure deadlines (dates after which customary units will no longer be authorized) have been used for some industries or products. This has been the practice in South Africa and Australia; the reasons given for closure (which is legislated) are to prevent backsliding and the accrual of economic advantage to those few companies retaining the customary system. In the U. S., closure regulations related to the bottling of wine and distilled spirits are cases in point.

Final conversion dates merit brief mention. First, no known nation or other organization has published a fixed date of final, complete conversion. There are many estimates, particularly after the conversion process is well under way, of dates when the nation or company will be "substantially converted". Some converting companies do not bother to publish final conversion date estimates. These target dates are of some interest to the Army in planning its conversion; however, dates for accomplishment of major identifiable events (milestones) will be more useful in making a realistic plan. One such milestone of particular interest may be the date after which specific new product(s) will be designed in SI. As indicated in our Task A Report, milestones that obviously impact on metric conversion decisions of the following kind are important to establish and to be aware of the planned event(s).

Cooperation by major basic material industries was of major importance to Australia's conversion effort. For example, the Aluminum Development Council of Australia (Ltd.) in October 1973 published Metric Conversion Data for Australian Aluminum Mill Products which announced that the industry would process only metric orders after 1 January 1974. This gave users three months to go metric. After that date, orders would, for a time, be converted to soft metric if the user did not specify metric--invoices would be in metric regardless of the user's order specifications.

A second major material industry, The Broken Hill Proprietary Co., Ltd. (BHP) announced its BHP Sections - Metric Properties and Availability in July 1972. The publication listed a revised set of preferred metric dimensions (with imperial equivalents) which alone would be utilized by BHP after 1 March 1973.[15]

Lessons Learned

1. An evolutionary Army metric transition will be the least costly and most effective.
2. Metrication of all Army activities concurrently, at rates suited to each, will be most effective.
3. Realistic and flexible timetables for significant metrication milestones can serve as useful Army planning and management tools.
4. Good planning of the metric conversion activities will minimize the impact of metrication on the Army user.

Problems for the U. S. Army

Good planning is the key to an effective conversion. The U. S. Army must assure that metrication planned be assigned a high priority. Adoption of a non-evolutionary mode of conversion will result in substantial, unnecessary costs. Care must be taken to ensure both coordination and flexibility in planning.

MODE OF CONVERSION NOTES

1. Report by the Minister of Education and Science on The Operation of the Metric Conversion Act 1970-1971 for the period from the appointment of the Board to 30 June 1971 in Metric Conversion Board, First Annual Report for the year 1970-1971.

2. Letter from John T. Benedict of Chrysler Corporation, August 31, 1977, in response to FI Survey of U. S. Industry.

3. Letter from J. G. Langenstein of Caterpillar, August 29, 1977, in response to FI Survey of U. S. Industry.

4. Letter from M. E. Smith of FMC, September 8, 1977, in response to FI Survey of U. S. Industry.

5. Letter from Everett L. Baugh of GM, August 26, 1977, in response to FI Survey of U. S. Industry.

6. "Honeywell Approach to Metrication," in Metric Conversion in Engineering and Manufacturing, American National Metric Council Report ANMC 74-1, 1974.

7. Letter from L. J. Rankine of IBM, September 12, 1977, in response to FI Survey of U. S. Industry.

8. A. F. A. Harper (Executive Member Australian Metric Conversion Board) presentation: "World Perspective in Conversion to the Metric System" in Report of April 1975 Conference Metrication: The Australian Experience.

9. Australian Metric Conversion Board Seventh Annual Report for the Year 1976-1977.

10. "Metric Conversion at Addressograph-Multigraph," in Metric Conversion in Engineering and Manufacturing, ANMC 74-1, 1974.

11. Letter from E. B. Ash of Rockwell International, September 12, 1977, in response to FI Survey of U. S. Industry.

12. Letter from J. E. Anthony of Brunswick, October 4, 1977, in response to FI Survey of U. S. Industry.

13. Letter from A. H. Phillips of Boeing, August 25, 1977, in response to FI Survey of U. S. Industry.

14. Letter from R. R. Billings of Beech, August 16, 1977, in response to FI Survey of U. S. Industry.

15. Forecasting International, Ltd., DARCOM Metrication Final Report on Task A: Foreign Experience, Volume 1, November 8, 1977.

4.4.2 Management and Organization

Management's attitude toward metric conversion will shape the methods used to achieve metric conversion and the success of the program. U. S. industry experience emphasizes the importance of a "business-as-usual" approach.

> *Important to metric transition progress is a strong attempt to retain and emphasize a "business-as-usual" atmosphere. Metric planning should be devoid of emotion as much as possible and should be conducted with a distinctly low-key emphasis. Undue attention drawn to the metrication effort can create problems where none should exist and tip the balance needed in striving for a progressive yet stable situation.*[1]

In maintaining this philosophy at Honeywell,

> *Metrication is handled as a new technology with very broad impact and information flow is handled through inter-divisional standards channels.*[2]

Similarly, IBM notes:

> *There have been no special considerations given to the management of the changeover to metric. It is being managed as a part of our normal business activity in the same manner as the change from fractions to decimal dimensioning or the adoption of any new procedure or standard.*[3]

Top level management generally fills three major roles in organizational or national conversion. These are: 1) to provide continuing, defined high level commitment to metrication; 2) to serve as a coordinating focus where corporate or national activities require coordination; 3) to act as a clearinghouse for information exchange and facilitate communications throughout the organization and with external groups where necessary. Each of these roles and functions is discussed in some depth in other sections of this document. The following discussion will focus on organizational structures and management policies to achieve a least-cost, evolutionary transition.

Organization of the national metric conversion varies among the countries but a common theme of organization is the use of existing groups and structures as much as possible. In Sweden, the Swedish Standards Institution and the National Laboratory for Materials Testing spearheaded the conversion. In South Africa and Australia, where conversion is more complex, national boards (Metrication Advisory Board and the Metric Conversion Board, respectively) were set up. The Metrication Advisory Board is part of the South African Department of Commerce and the Metric Conversion Board is under the Minister of Science. These groups serve as the overall coordinating and advisory bodies for national conversion. The establishment of these Boards represents a new organizational structure, but membership on the functional committees is heavily drawn from existing organizations which provide expertise in the spectrum of fields and sectors impacted by metrication. There is basic agreement among all the countries surveyed that the membership of functional committees of the Board should be as broad as possible, encompassing elements of <u>all</u> groups of society that would be affected by conversion. Industry, government, standards organizations, the military, consumer groups, trade associations, labor representatives, small businesses, professional organizations, etc. are all involved in planning, implementing and monitoring conversion.

A second area of agreement is that membership on these functional committees should comprise individuals of the highest caliber and who are directly responsible for implementing conversion in their home organizations.

Foreign experience emphasizes the need for highly participative widespread efforts crossing functional and hierarchical lines. There is an emphasis on the temporary nature of the task and the use of task forces and ad hoc groups rather than the formation of a separate long-term organization.

U. S. industrial experience with metrication parallels foreign practice to a great extent. As John Benedict of Chrysler Corporation points out,

> *The accepted general management strategy is to embody metric management into the existing organization structure. The objective is to undergo a realistic and practical change. The advantage of this approach is direct management control -- which enables cost-effective programming.*[4]

All the experience examined in preceding studies by FI shows that any organizational modification which dilutes line management responsibility for achieving metric conversion will only serve to impede the process. Those who plan conversion must be the ones to carry it out. Consequently, the organization can be a very small one. It serves to expedite, coordinate and provide information.

U. S. industry experience indicates that metric conversion is successfully managed using normal management channels. Few companies have a full-time person working on metrication. Nonetheless, industry has erected several variants of a basic organization structure to manage metric conversion. This organization is generally characterized by the following:

- o Few dedicated (paid) positions;
- o Wide participation at all organizational levels;
- o Reliance on committees whose members, in their normal line capacities, are responsible for implementing metrication policy;
- o Decentralized decision-making and execution.

The organization set up is often ad hoc, with advisory capabilities. The committees are comprised of high level officials in the company and the committee or coordinator reports directly to top management at the Vice President or higher level.

Membership on the corporate committees is broad, covering all aspects of corporate activity--not just the engineering and operational

aspects. Committee membership generally includes representatives from legal, accounting, financial, personnel, public relations and other aspects as well as the production side.

The following comments from various U. S. corporations indicate the nature and structure of the organization set up to facilitate metric conversion.

At Caterpillar:

> *A corporate committee was created consisting of representatives from all departments involved. This committee, chaired by a Manufacturing Vice-President, developed corporate policy statements. This committee now meets only when required on policy matters.*
>
> *A second corporate committee, which is still active, was created in mid-1975 for the purpose of coordinating the conversion to standard metric material sizes. This committee is chaired by a Materials staff engineer with other members representing Engineering, Standards, Purchasing, Manufacturing, and Data Processing Systems.*[5]

At Chrysler:

> *With the Engineering Office in (the) lead role, a Corporate Metrication Committee was established... With committee membership assignment emanating from Corporate Group Vice President level (where appropriate), the committee makeup includes all major Corporate functions and activities...and each organizational unit devised its own individual Metrication Plan. The Corporate Plan is, in essence, an integration of all individual plans -- and there has been no separate, detailed planning document issued at Corporate level. Defense activities are integrated with Corporate planning through Defense Group membership on the Corporate Metrication Coordinating Committee.*[6]

At General Electric:

> *The General Electric Metric Council is composed of representatives from each of the principal components of the Company. Within these principal components there are also metric councils. The Council considers metric conversion as it affects the Company. It communicates information on metric conversion throughout the Company. Its purpose primarily is to assist operating management in considering, planning, and implementing metric conversion. The representatives*

on the General Electric Metric Council are chosen by the management of the Groups they represent. The chairman is a consultant in the Corporate Technology Staff.[7]

At Honeywell:

Each operation has a metric coordinator who may or may not have a local committee with representatives of various departments. When a local committee exists, it consists of representatives of all phases of the organization (e.g., engineering, manufacture, etc.). The metric coordinators at various operations form a Corporate Metrication Committee. The primary function of this corporate committee is to exchange information and establish common standards.[2]

At Texas Instruments:

Our Corporate Metric Implementation Committee is assigned the responsibility for setting policy and guidelines on all matters pertaining to metrication, establishing sources of information, dissemination of information concerning conversion procedures and formation of task oriented subcommittes to define specific issues. Members of the Committee represent both organizational and functional activities, to assure adequate representation across the Corporation, and the Committee Chairman reports at the Corporate Vice-President level.[8]

At IBM:

To achieve metrication throughout the Corporation, an SPA (Standards Project Authority) was set up to coordinate the implementation of the new system. The SPA works through the Metric Interdivisional Steering Group, which consists of those individuals responsible for metrication at each operating unit, to coordinate effort, avoid duplication and resolve problems mutual to the various units. The members of the group work through representatives from their various location function representatives to bring the program to the employees who have a need for the system.[3]

At Sperry Vickers:

(A) metrication committee coordinates interfunctional involvements and is advisory to management and product committees. (The Company) plan sets broad guidelines such that we trend toward metric while allowing strategic planning to be properly influenced by requirements of the marketplace and economics of metric vs.

conventional manufacturing material. Specific new policy is established by management.[9]

Hewlett-Packard's approach to metrication is less formal than some of the other companies.

H-P established 1 position (Corporate Metrication Coordinator). There are 40 part-time divisional coordinators arranged in an informal matrix organization. The role of the CMC is to provide guidance and information, not directives.[10]

As the foregoing comments indicate, common characteristics of metric coordinating committees are:

- o Headed by or reports at Corporate Vice-President or higher level. Generally report to VP of Manufacturing, Technology or Engineering.
- o Representation on committee from all corporate departments, functions and activities.
- o Usually informal organizations. Membership participates in addition to normal corporate duties. Only two respondents stated that they had one or more individuals, usually metric coordinators, who performed this task on a full time basis.
- o In most cases, committees have no formal authority and are advisory to both high level corporate staff and divisions.

There is some kind of official or unofficial method and organization for dealing with metric issues, e.g., committee, coordinator, lead department. Several broad responsibilities of these individuals and groups are identified. The major objective of the committee or coordinator is "to provide guidance and policy for programs and departments involved in metric design, procurement and manufacture"[11] in light of corporate policy. To accomplish this broad objective, the committee, coordinator or lead department is charged with the the following tasks and responsibilities:

- o Collect and disseminate pertinent information:
  - o stay abreast of industry change
  - o review status of legislation, government policy, customer specification, etc.
- o Coordinate conversion:
  - o establish requirements for in-house change and order of change
  - o assist planning at operational level
  - o facilitate communication among divisions
  - o avoid duplication of effort
  - o establish company-wide standards
- o Resolve problems
- o Serve as contact point for outside organizations
- o Set up task-oriented subcommittees.

The day-to-day decision making and planning regarding metric conversion is made at the divisional or operational level of the corporation. Those who must implement conversion make the decisions and the plans.

> *The objectives of the management strategy are to avoid new organizational or managerial elements and delegate responsibility for SI planning and implementation to the operating levels. This was to facilitate metric planning within the mainstream planning cycle and to permit realistic control of expenditures.*[12]

Decentralization of decision-making for day-to-day business is a common practice in the large U. S. companies. Decision-making regarding metrication is typically handled by the same decentralized process, with guidance offered by the Corporate Policy Statement(s) and the Corporate Metric Committee.

The following comments from U. S. companies illustrate this practice.

At FMC,

> *The decision of when to convert is left up to the individual division. No corporate-wide timetable has, or will be established. FMC's business interests are too varied to permit setting up a corporate master plan. Some divisions may be substantially metric in as little as five years while others may still be 15 or 20 years away. Even though each division must set its own pace, the steps each one must take to reach a position of being substantially metric are similar.*[13]

General Electric stated:

> *The General Electric Company participates in many businesses. The decision on whether and when to convert on each specific business will be made by the management of the operating components involved. The Company position is that conversion is to be done as it becomes economically justifiable for each industry, and with consideration for and involvement of the users of the products involved.*
>
> *I am unable to predict now when the Company will be substantially converted. The time of conversion by its many operating components will vary greatly. A phase by phase description of our transition does not exist.*[7]

At Honeywell,

> *A decision to convert U. S. operations to the metric system was made in 1972. We expect to be substantially converted by 1987.*
>
> *Since each Honeywell division has a high degree of autonomy, the approach to metric transition has varied significantly. In general, however, a two-pronged approach has been used and (1) dual-dimension technical literature and product specifications and (2) initiate metric design on a trial product preparatory to using metric in all new product design. Use of the metric system in non-product related operations will depend on the general U. S. conversion status.*[2]

Singer stated,

> *Singer is a diversified, decentralized, multinational company. Involvement with SI ranges from ignoring it to deep involvement. Company policy*

is to leave the metric decision to subordinate divisions/plants. The decision is based on customer needs.[14]

Westinghouse stated:

In the absence of a law mandating conversion to the metric system, we believe that the normal market forces of benefits and costs will determine which industries will convert and at what rate conversion will take place. Westinghouse's product lines are highly diversified and our divisions operate in a wide spectrum of industries and markets. Each division general manager is responsible for the operating statement of his division and we therefore believe it appropriate that each division, with guidance and assistance by corporate staff, should make the decision when and at what rate it should convert. We do not intend to edict conversion on a corporate basis.[15]

While industry experience indicates the necessity of highly decentralized decision-making regarding metrication, John T. Benedict of Chrysler Corporation indicates that it is not always as easy as it sounds.

Metrication is to become a part of every manager's responsibility. It will be regarded as a regular part of his job. It is to be accomplished as an added function, performed within the existing organizational structure -- and through normal channels and working relationships.

An aspect of metrication management that requires careful attention is the need for a balanced, well-modulated approach that administers the on-going activity so that the many diverse areas move in concert. The "balancing act" requires, on the one hand, constraint against haphazard, premature or precipitous action...and, on the other hand, the need to delegate responsibility and foster initiative.[16]

The decentralized decision-making and implementation of metrication offers several advantages as numerous individuals have pointed out. The key advantage to the organization is that the doers, who should be the planners, are the most familiar with their areas of responsibility. Metrication presents questions and problems that must be

dealt with and these individuals are best qualified to handle these problems. It is one of the elements of assuring a least-cost metric conversion.

Lessons Learned

1. Foreign and U. S. industry experience indicates metrication requires only a small organization, with a top level review committee, to coordinate, expedite and inform.

2. Top level review committees should include members from all elements of the organization.

3. A low-key, business-as-usual attitude, treating metrication as a new technology or new procedure, works well in U. S. industry especially for companies used to dealing with new technologies on a frequent basis.

4. Day-to-day dealings with metrication requires decentralized operations and decision-making functions.

5. The major functions of top management are:

   o to provide a continuing and firm commitment to metrication;

   o to coordinate metrication activities;

   o to ensure communications among internal and external groups.

6. Those who must implement conversion should be the planners.

7. Ad hoc and/or informal working groups are frequently used in corporations to deal with metrication problems and issues.

Army Problems and Opportunities

Viewing metrication as similar to a new technology or procedure with broad impact appears to be a viable approach for the U. S. Army to employ since the organization is used to dealing with new technology frequently. The normal organizational structure of many large corporations, with its groups and divisions below the corporate level, parallels the Army's command structure quite closely. This would suggest that industry's metrication organization could be suitable for Army application.

MANAGEMENT AND ORGANIZATION NOTES

1. Lowell W. Foster, "Company Metrication Strategy and Planning Guidelines," in ANMC, Managing Metrication in Business and Industry (New York: Marcel Dekker, Inc.) 1976.

2. Letter from Alonzo R. Parsons of Honeywell, Inc., August 3, 1977, in response to FI Survey of U. S. Industry.

3. Letter from L. J. Rankine of IBM, September 12, 1977, in response to FI Survey of U. S. Industry.

4. John T. Benedict, "Cost Management," a paper given at the ANMC Conference, Washington, D. C., April 6-7, 1976.

5. Letter from J. G. Langenstein of Caterpillar Tractor Co., August 29, 1977, in response to FI Survey of U. S. Industry.

6. Letter from John T. Benedict of Chrysler Corporation, August 31, 1977, in response to FI Survey of U. S. Industry.

7. Letter from W. R. Kruesi of General Electric, August 22, 1977, in response to FI Survey of U. S. Industry.

8. Letter from E. James Tew of Texas Instruments, October 14, 1977, in response to FI Survey of U. S. Industry.

9. Letter from R. L. Hildebrandt of Sperry Vickers, October 7, 1977, in response to FI Survey of U. S. Industry.

10. Phone conversation with John Bogren of Hewlett-Packard, October 3, 1977.

11. Letter from A. H. Phillips of Boeing Aerospace Corporation, August 25, 1977, in response to FI Survey of U. S. Industry.

12. Lewis Branscomb, "Cost Implications of Increasing Metric Usage," in ANMC, Metrication--Cost Considerations, Metric Conversion Paper #2, 1974.

13. Letter from M. E. Smith of FMC, September 8, 1977, in response to FI Survey of U. S. Industry.

14. Phone conversation with J. van Duyne, Singer Co., August 19, 1977.

15. Letter from David H. Fax of Westinghouse, September 19, 1977, in response to FI Survey of U. S. Industry.

16. John T. Benedict, "The U. S. Automobile Industry in a Metric World," paper given at Society of Manufacturing Engineers Conference, Romulus, Michigan, August 21, 1973.

4.4.3 Coordination and Communication

The need for continuous and effective coordination and communication is repeatedly stressed by foreign and U. S. industrial sources. Coordination and communication are vital not only within an organization but with interacting bodies outside it as well. If the Army is to keep pace with industrial metrication, appropriate and effective coordination with standards-writing bodies, suppliers, contractors, and planning groups, such as ANMC and the U. S. Metric Board, will be absolutely essential.

Within the Federal government, metrication coordinating bodies are generally in the formative stages and the relationships among them are in a state of flux. The Interagency Committee on Standards Policy (ICSP) formed a Metrication Subcommittee in 1976 to communicate and coordinate metrication activities among the Federal agencies, and to provide liaison with the then authorized but memberless U. S. Metric Board. This Subcommittee, representing 43 agencies, subsequently formed eight divisions, two of which (construction and procurement/purchasing) are currently chaired by DoD members.

The Subcommittee recommended in 1977 that an independent interagency committee be formed to make high level policy decisions. This Committee (Interagency Committee on Metric Policy (ICMP)) is now being formed. The Committee will be responsible for:

1) Resolving differences among Federal agency metric programs;

2) Providing executive liaison with the U. S. Metric Board;

3) Recommending conversion plans and policies for the Federal government in those areas where more than one agency has a primary interest (e.g., transportation, construction, consumer affairs).

Meanwhile, the U. S. Metric Board was established when the first 13 nominees were confirmed by Congress on March 21, 1978 and were subsequently sworn in on March 31, 1978.

The fate of ICSP's Metrication Subcommittee is not clear; it may very well become attached to the ICMP as the latter's working group. In any event, these two bodies currently represent the principal forums for Federal metrication planning and the Army's avenue (via DoD) to the U. S. Metric Board.

Most companies participate extensively in the development of both industrial and international standards; suitable industry of international standards obviate the need for a company to develop its own. (Other purposes may be to take advantage of material or product rationalizations as they are introduced, and to gain technical and commercial intelligence useful to their programs.) While companies do develop their own standards as the need arises, industry experience again emphasizes the necessity to stay current. Otherwise, so-called standardization will result in conflicting or redundant standards or in the loss of opportunities to rationalize varieties, sizes, etc. Participation in standards groups can also be one of the most effective ways of achieving rationalization.

These same reasons for extensive involvement and participation would appear to be valid for the Army. Particular emphasis on developing international standards and participation in the development of U. S. industrial standards which meet military requirements could be a means of reducing the total number of Federal and military specifications and standards.

Coordination with suppliers is frequently mentioned by the companies surveyed as an area deserving special attention. General Motors, with its 40,000 suppliers, provides a vivid example of the kind of coordination necessary to assure the success of a major metrication effort. The company is quoted as saying, "Let nothing be a surprise to them." GM established two-way communications by asking advice of its vendors and including them in GM's planning.

Considering the tremendous leverage that General Motors exercises over its suppliers, this lesson could be a particularly valuable one for the Army. With its smaller budget, the Army will necessarily

exercise a lesser leverage. As a result, cooperative two-way communications become even more important.

Ability to sense the external environment and the changes evolving is the means of determining the timing of metric conversion within the Army. The Army can utilize the same methods that industry does to accomplish this purpose although the Army's needs may differ from those of industry.

In order to assure a minimum cost conversion, the Army must first evaluate industrial progress to determine the current standing of the different sectors. It is important for the Army to know which sectors are in the lead and where priorities of effort must be placed to keep pace with those sectors advancing more rapidly. It must then maintain contact with industry throughout the entire process.

The importance of this overall question cannot be over-emphasized. As pointed out elsewhere, the Army (or DoD, for that matter) cannot dictate terms to U. S. industry on the basis of economics: the leverage is simply not there. Moral persuasion through the good offices of the American Defense Preparedness Association and other patriotic organizations notwithstanding, the Army's ability to influence industry on a national basis is limited. As a result, if the Army specifies that equipment be in metric units before industry is ready, it will most likely bear an increased cost burden.

In addition to standards-writing groups and suppliers, companies are also active in organizations involved in planning and coordinating the metrication process, particularly the ANMC. Participation in the work of ANMC Sector Committees is currently one of the best means of maintaining contact with industrial metrication and influencing the nature, direction and timing of the process. The importance of participation in the ANMC is highlighted by recent developments: the dissemination of six draft sector metrication plans; and the endorsement, by the USMB in its first resolution, of the ANMC's continued role in national metrication. Furthermore, a practice of submitting

coordinated sector plans to the USMB for approval appears to be emerging.

Participation in the work of ANMC Sector Committees also implies active two-way communications whereby the Army, while gaining first-hand industry information, would be able to inform industry at the working level of Army metric planning and needs. Participation would help reduce the transition period by closely coupling Army requirements with industry's capabilities; participation would also suggest initiatives for actions advantageous to the Army and ways in which the Army might realize the benefits of metrication.

There is another vital element of the coordination process--internal communications and information exchange within the Army. Because many people are concerned with the aspects of metrication which are of general or particular interest to others in the Army organization, there must be an effective interchange of metric information among all. Metric developments in one industry, or even in one large company, will usually affect more than one Army organization. There are a number of ways to exchange metric information among and within Army organizations, but unconstrained informal communications will best assure effectiveness.

Lessons Learned

1. Effective coordination and communication are essential to assuring a least-cost metric conversion.

2. Coordination is a multi-faceted problem of maintaining active informal two-way communications with outside groups, with other DoD agencies, among major Army commands and staff agencies, and with subordinate units.

3. There is a need to establish the identity, cohesiveness and sense of purpose among individuals concerned with metrication. There is a need to mesh the metrication information and coordination network with the decision-making network.

Army Problems and Opportunities

While individual companies or industry sectors have many characteristics in common with the Army, there are none that possess all of the unique characteristics peculiar to the Army and its operations.. In some respects, the Army differs markedly. For example, geographic dispersion, the type and complexity of its activities, the wide range of products and materials handled, the potential variability of usage rates between peacetime and combat operations, all militate against any direct comparison of Army and industrial coordination experience and illustrate the greater difficulties in maintaining effective communications and coordination within the organizations.

Currently, most commands monitor, to varying degrees, those industries appropriate to their functions, through direct vendor contact and through employee participation in technical societies. However, the regularity with which information is obtained varies widely, depending on the state of industrial metrication and the Command's perceived need for the information. Only four of the Commands report active participation on appropriate ANMC sector committees.

Currently, there is a general lack of metrication information available among DARCOM Major Subordinate Commands; communication is particularly weak between Commands, and with DARCOM. The Commands desire guidance and leadership from DARCOM, but they also desire a voice in preparing metrication plans and directives which will affect them. There are many questions regarding funding and the handling of metrication costs. This indicates that considerable attention needs to be directed towards setting up more effective communciations and coordination channels.

4.5 Some Major Details

Through the detailed study of both foreign and domestic metrication experience, several specific areas of interest with respect to metrication have emerged. These include: Standards and Specifications; Hybridization; Training; The Use of SI Units, Other Units and Preferred Multiples; and Automated Data Processing. Detailed planning is necessary to ensure that the implications of these issues are fully considered. In the following subsections, each of these issues is discussed in some depth. The discussions highlight problem areas, solutions, and associated planning needs.

4.5.1 Standards and Specifications

There can be no doubt that military standards and specifications as well as federal and industrial standards play a major role in adoption of the SI-metric measurement system by DoD and U. S. industry. The questions of rate of conversion of the documents and hard or soft conversion also play an important role in determining how fast U. S. industry is likely to convert to SI. William T. Cavanaugh of ASTM, in the ANMC 1976 Annual Report, indicates:

> *Standards are the language of modern technology; as technology changes, standards must also change. Any change, however, will be dictated by the marketplace. Changing to metric terms and sizes should and will be a result of "demand-pull" rather than "technology-push". Metrication cannot be forced and standards cannot predict or determine future product performance or technology.*

In the same publication W. T. Cavanaugh indicates "A complete change to hard metric dimensioning of products will cover many decades regardless of government pressure or existence of standards."

Domestic standards in customary units (including, but not limited to, American National, Federal and Military) number in the tens of thousands (see Figure 4-8). Any item of military hardware may invoke in its description dozens or hundreds of standards and specifications in a complex and interrelated array (see Figure 4-9). The prospect of rewriting so many documents in metric is awesome. However, a practicable, two-pronged approach has been undertaken by U. S. industry and industrial standards-writing bodies: soft conversion of existing standards, and development of new hard metric standards for new designs (see Figure 4-10).

This approach has begun to be paralleled within DoD/DA where specifications are being soft converted as part of the normal review process, and there is some Army participation in industrial standards-writing bodies. Some indication of the magnitude of the task can be observed by examining Figure 4-11.

FIGURE 4-8

ESTIMATE OF SPECS/STDS FOR WHICH DOD AGENCIES ARE PREPARING ORGANIZATIONS

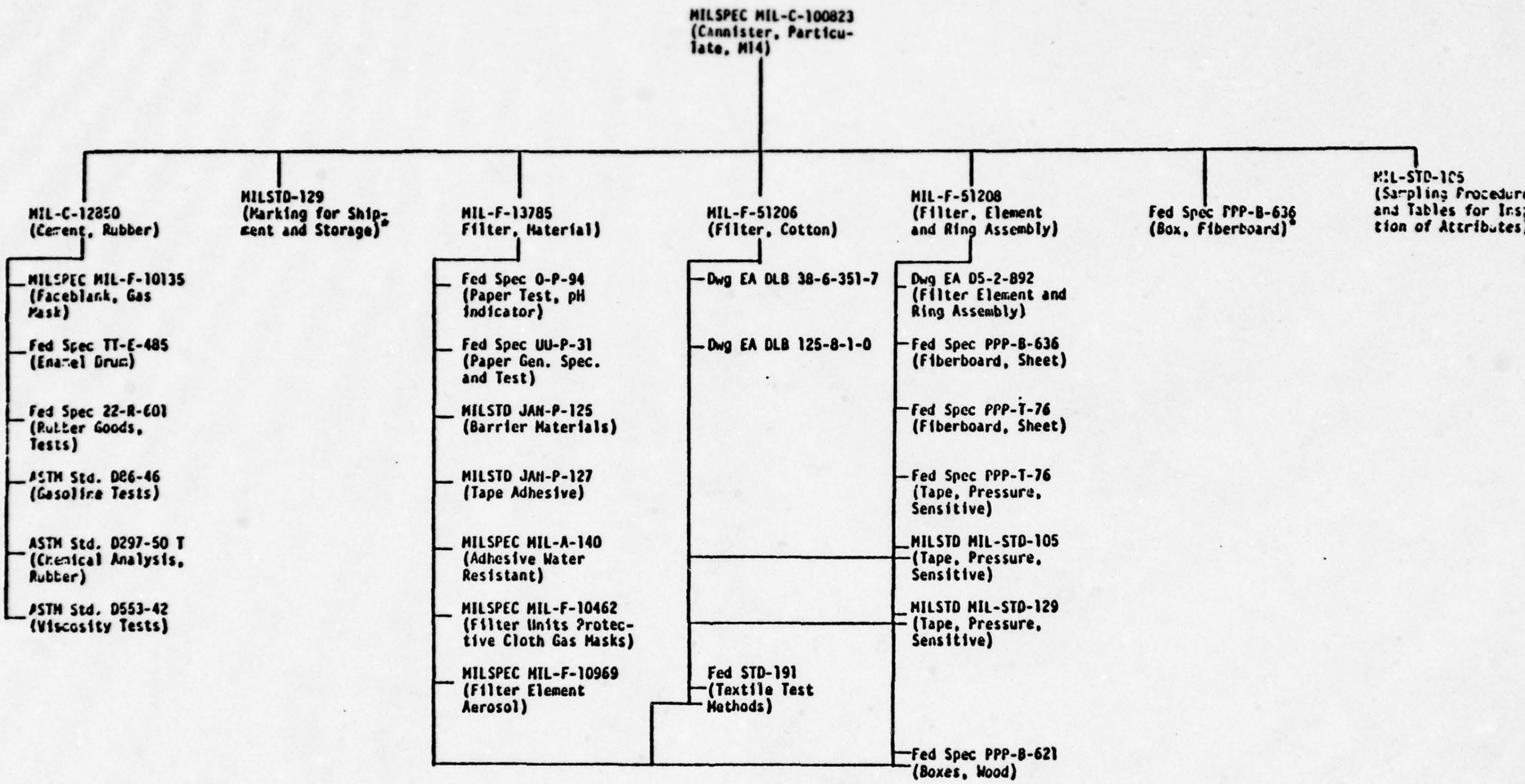
(1 September 1977)

MilSpecs		26,997	(Count)
MilStds		5,704	(Estimate)
FedSpecs		2,606	(Estimate)
FedStds		1,046	(Estimate)
Federal Information Processing Standards		32	(Count)
Industrial Standards		1,220	(Count)
International Std -	Navy	124	(Count)
	DoD	7	(Count)
	USAF	583	(Count)
	Army	324	(Count)
USAF ANA Stds		570	(Count)
	TOTAL	39,213	

*Forecasting International, Ltd., Task B, Domestic Experience Report.

FIGURE 4-5

FIRST, SECOND AND THIRD LEVEL SPECIFICATION AND STANDARD RELATIONSHIPS TO A PRIMARY SPECIFICATION **



*Not investigated further.

**Forecasting International, Ltd., Task B Report on Domestic Metric Experiences.

FIGURE 4-10

METRIC STANDARDS DEVELOPMENT IN 5 MAJOR STANDARDS-WRITING ORGANIZATIONS*
(January 1975)

Standards-Writing Organization	Total No. Standards Sponsored	American National Stds. Sponsored %	American National Stds. Sponsored No.	SI Converted Soft %	SI Converted Soft No.	SI Converted Hard %	SI Converted Hard No.	100% Converted Target Dates Soft Dual	100% Converted Target Dates Soft SI	100% Converted Target Dates Hard
API	500	25-50	125-250	<25	<125	--	--	1979	1984	--
ASTM	5100	50-55	2550-2805	~95	4845	0	0	1975	--	--
ASME	440	98	431	10	44	<1	2	1977	1983	--
IEEE	350	33	116	~98	343	--	--	--	--	--
SAE	6000	10	600	75	4500	<25	<1500	--	--	--
TOTALS	11390	34-37	3822-4202	87	9857	<13	<1500			

*Derived from ANMC Report, Status of Metric Standards Development in the U. S. A.

FIGURE 4-11*

DISTRIBUTION OF MILSPECS

(Thru 1 September 1977)

Preparing Organization	No. of MilSpecs
Total DoD	26,997
DSA	1,668
U. S. Navy	9,595
U. S. Air Force	3,821
DA (Non-DARCOM)	939
NASA	10
Unknown	3

*Count from DoD Index of Specifications and Standards, Part II, Numerical Listing 1 July 1977 and Supplement Part II Numerical Listing, 1 September 1977.

There are also existing processes for reviewing industrial and Federal standards and specifications for military applicability, and for weeding out duplicate specifications. These tasks can be expected to increase as metrication progresses. Figure 4-12 indicates the potential magnitude of the Federal standards and specifications conversion task. As indicated there appears to be about 65% that are under DoD cognizance.

An appreciation of the sheer magnitude of the task confronting DARCOM elements can be gained through examination of Figure 4-13.

Of course, not all standards and specifications are dimensionally sensitive. Therefore the numbers may be much less than given in the preceeding discussions.

> *The U. S. Metric Study Report suggested that some 20,000 standards might fill the needs of an industrialized society like that of the United States. A further refinement indicated that of the existing international standards some 25 percent were dimensional specifications; hence, it might be concluded that attention should be focused on the development and application of approximately 5,000 engineering standards that are primarily measurement-sensitive.*[1]

The complexity of the problem has not changed since Donald R. Mitchell (Defense Materiel Specifications and Standards Office) expressed these thoughts in 1975 to the 24th Annual Conference of the Standards Engineers Society.[2]

> *Because of the diverse nature of products with which we are concerned, we cannot logically follow our own independent conversion schedule, but must gear our efforts to the conversion rates of the various sectors of industry. If we try in any sector to push conversion faster than the industry in that sector is ready to change, we stand in danger of incurring unnecessary costs on at least two counts. First, it would be expected that if we attempt to force conversion, the industry's start-up conversion costs, such as training, machine tool changeover, and manual revision, would be borne by the DoD as part of DoD's purchase cost. Second, if by rushing in too early we established metric standards different from the standards which the industry as a whole decides*

FIGURE 4-12*

FEDERAL STANDARDS AND SPECIFICATIONS

	Approximate Total No.	Preparing Agency DoD No. (Approx.)
Federal Specifications	4,975	2,600
Federal Standards	1,575	1,045
TOTALS	6,550	3,650

*Count from GSA Federal Supply Service, Index of Federal Specifications and Standards, FPMR 101-291, 1 January 1977.

FIGURE 4-13

DISTRIBUTION OF MILSPECS

DARCOM Subtotals

(Thru 1 September 1977)

Preparing Organization		No. of MilSpecs
US Army Armament R&D Command		4,084
Aberdeen Proving Ground, Md.	810	
Dover, N. J.	1,713	
Frankford Arsenal, Pa.	1,213	
Rock Island, Iowa	348	
US Army Aviation Systems Command		43
US Army Electronics Command		2,577
US Army Maintenance Management Center		38
US Army Materials & Mechanics Center		315
US Army Missile R&D Command		492
US Army Mobility Equipment R&D Command		1,389
US Army Natick R&D Command		1,494
US Army Tank-Automotive Materiel Readiness Command		478
DARCOM Packing, Storage & Containerization Center		2
Armament Laboratory, Rock Island		5
Picatinny Arsenal		10
Watervliet Arsenal		34
TOTAL		10,961

upon, we would face a two-step conversion process with the supply problems that go along with it; that is, we would go from a customary standard to one metric standard and later to another metric standard. This we cannot afford.

Instead, we must pace our conversion, generally, to the rate of conversion at which the various sectors of industry are ready to proceed. This means we will, to a larger degree than any individual company certainly, be moving at many different rates. For a large weapons system that might stay in production for a long while, this could result in a configuration and technical manual manager's nightmare, with many components changing to metric over the life of the production run. This problem would be expected to multiply many times in supplying and maintaining this weapons system. Hard decisions will have to be made based on the economics of the situations at the time, whether to keep the customary components for the life of the item or change them to metric as the various component manufacturers convert their standard lines.[2]

An understanding of the U. S. voluntary production of standards will indicate the magnitude of the task resulting from metrication activities.

One requirement...is that committees responsible for standards development must have balanced membership from among the represented interests concerned with the specific project. The purpose is to ensure that no one interest can dominate the proceedings. Companies, per se, are not usually members of standards developing committees operating under ANSI procedures. Exceptions are made only where it can be shown that individual expertise is needed that cannot be furnished through national organizations or where a specific interest is not otherwise represented.

ANSI does not develop standards or gather evidence of consensus. These functions are performed by the standards developing organizations themselves. But in submitting proposed standards to ANSI for approval, these groups must certify that the following due process criteria have been met, presenting documentary evidence to this effect of making it available for inspection.

- *Individuals and organizations identified as being substantially concerned with a proposed standard's scope have been notified of the development project.*

- *All substantially concerned parties have been given an opportunity to participate in the development of the standard or to comment on it.*

- *Minutes of proceedings during the standard's development have been published and distributed on a timely basis; and notice has been given of all proposed actions on the standard.*

- *A ballot on the standard has been taken and negative votes and objections not withdrawn by the time of submittal have been addressed as required by ANSI.*

- *All participants and commentors have had an opportunity to appeal matters concerning the proposed standard. Rules of procedure, including an appeals method for both procedural and substantive issues, have been made known to those requesting this information.*[3]

The primary thrust to perform the voluntary planning for metric conversion has been borne by the American National Metric Council. Figure 4-14 indicates the ANMC organization that is providing voluntary metric conversion plans. Figure 4-15 illustrates the Sector Conversion Plan activity leading to U. S. Metric Board recognition of ANMC plans. To ensure the voluntary nature of ANMC activities, that organization

> *...has established procedures designed to minimize antitrust risks to the extent feasible under existing law. Basically, these procedures call for advance notice of meetings, public access to meetings and meeting records, limitation of discussion to previously announced topics, documentation of matters covered (so as to establish the substance of the action taken and thereby demonstrate that no improper activities took place), and mandatory participation by one or more parties whose interests are not aligned with the industry participants, i.e., by government, user or general interest members (so as to provide independent verification of the accuracy and reliability of documentation of the matters covered).*[4]

FIGURE 4-14

ANMC ORGANIZATION CHART

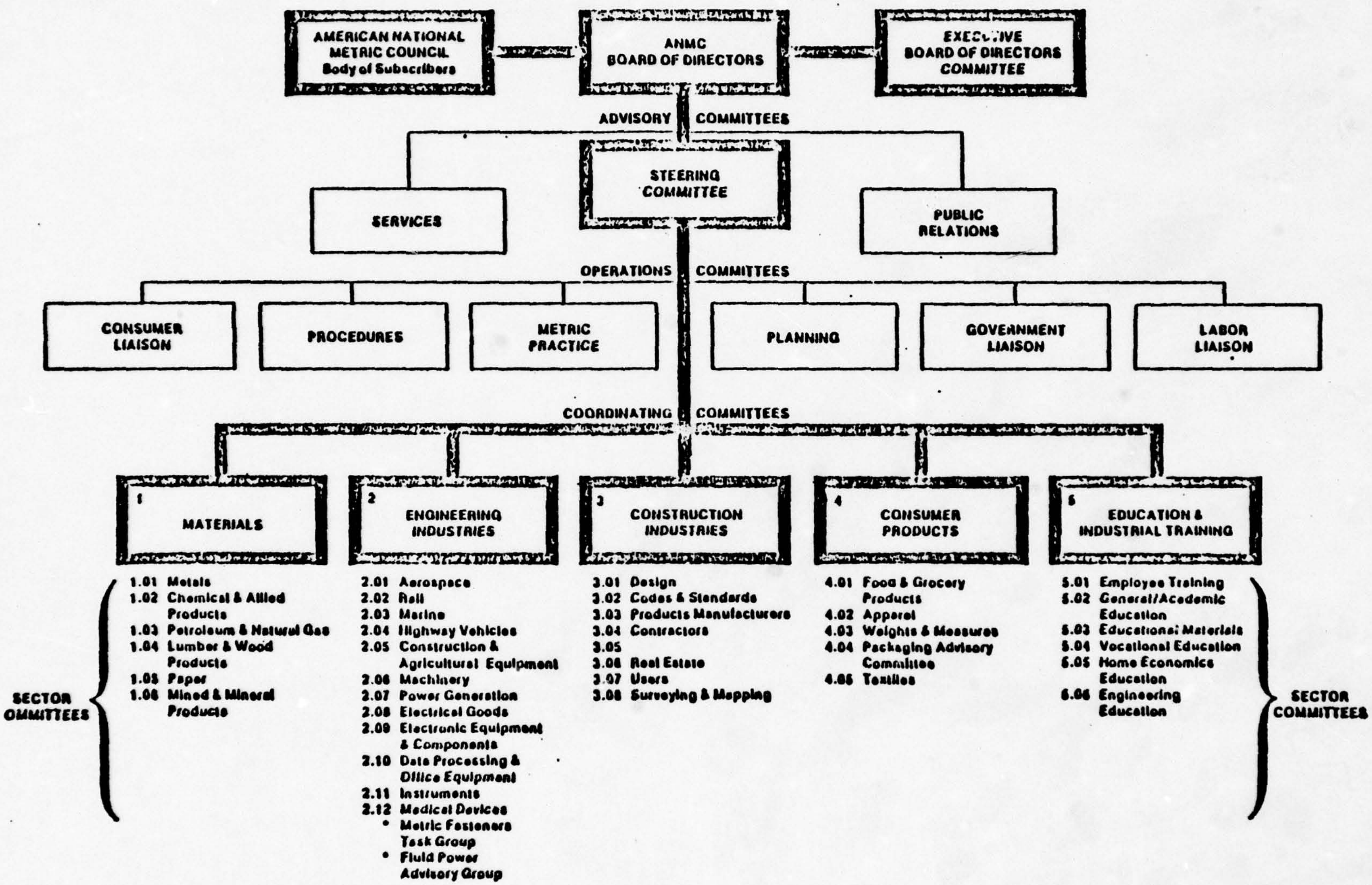
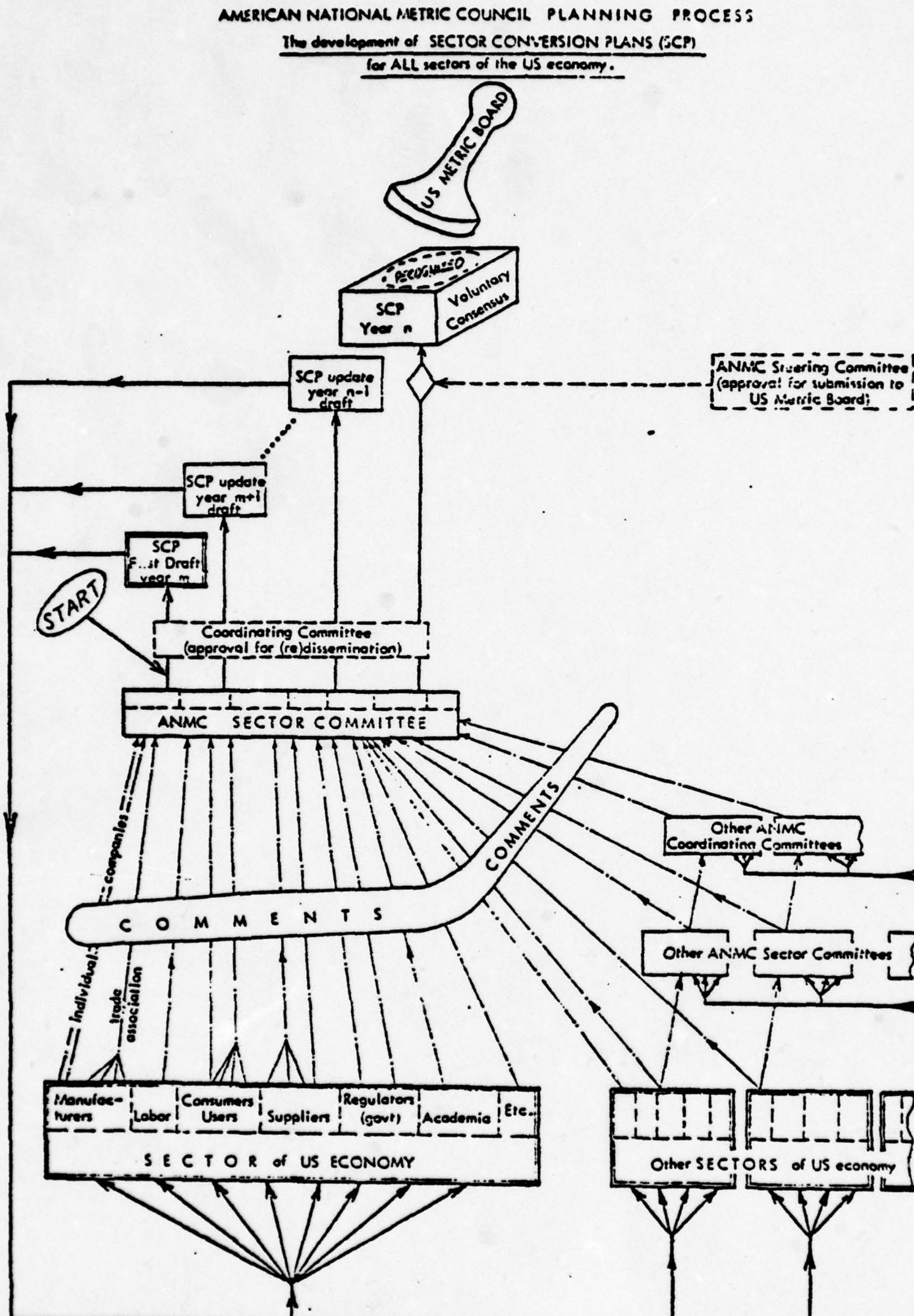


FIGURE 4-15


AMERICAN NATIONAL METRIC COUNCIL PLANNING PROCESS
The development of SECTOR CONVERSION PLANS (SCP)
for ALL sectors of the US economy.
US METRIC BOARD
RECOGNIZED
SCP Year n
Voluntary Consensus
SCP update year n-1 draft
ANMC Steering Committee (approval for submission to US Metric Board)
SCP update year m+1 draft
SCP First Draft year m
START
Coordinating Committee (approval for (re)dissemination)
ANMC SECTOR COMMITTEE
COMMENTS
COMMENTS
companies
individual
trade association
Other ANMC Coordinating Committees
Other ANMC Sector Committees
Manufacturers
Labor
Consumers Users
Suppliers
Regulators (govt)
Academia
Etc.
SECTOR of US ECONOMY
Other SECTORS of US economy

Indicative of the scope of ANMC Sector Planning activities is the April 1978 Major Activities List of the ANMC Metals Sector shown earlier on Figure 3-2.

Internationally, there has been increasing U. S. participation in the development of ISO standards; industrial participation is motivated by a desire for high quality standards compatible with U. S. industrial practice, as well as standardization. From an Army viewpoint, these considerations are equally important, as problems with foreign (non-ISO) standards (associated with U. S. ROLAND, for instance) will attest. Progress in NATO standardization depends in large measure on DoD/DA participation in the development of international standards.

Lessons Learned

1. The national effort to accommodate the workload on standards and specifications resulting from metrication is complex and involves many industrial and governmental organizations and various national institutions.

2. The DoD/Army complex can not undertake the metric conversion of standards and specifications on independently or on its own schedule.

3. Effort towards conversion of standards is progressing at a slow but accelerating pace through the voluntary standards-writing mechanisms.

4. Resources must be provided for DoD/Army participation in the conversion effort if the maximum to be gained from the effort is to be realized.

5. Soft conversion of Federal and DoD standards and specifications, in conjunction with their normal review, is a sound metrication practice which requires minimal additional effort.

6. Army participation in appropriate national and international standards-writing bodies will help assure that U. S. Army requirements are considered in the development of new hard SI standards, and will thereby help reduce the number of military standards which must be written and maintained.

Army Problems and Opportunities

The magnitude of the task of converting MilStds and MilSpecs is large, especially in light of the complex interrelationship of military standards and specifications with Federal and industry standards and specifications. The DoD/Army cannot convert its standards and specifications independently. It must be a concerted cooperative effort by all involved parties to ensure that DoD/Army gain the benefits available from conversion. This will require a commitment of funds, time and personnel to standards-writing activities. It will also require integrated planning.

STANDARDS AND SPECIFICATIONS NOTES

1. D. L. Peyton on International Standards--Impact on American Metrication in Metrication--Managing the Industrial Transition, Liptai/Pearson, ASTM Technical Publication 574--1975.

2. From ASTM Standardization News, February 1976, Metrication in the U. S. Department of Defense, Donald R. Mitchell.

3. D. Hogan, "In Defense of Voluntary Trade Product Standards," in MBA, April 1978.

4. ANMC, A Report to the Nation on the Management of Metric Implementation, January 1975.

4.5.2 Hybridization

A hybrid is defined in DoD-STD-1476 as "A combination or mixture of metric and inch-pound items". The concept of a hybrid product evolves naturally from cost considerations and the non-availability of suitable metric standards or metric module materials and parts, especially early in the transition. The following industry comments make this point with respect to the Army:

> *We feel that they represent a sensible, least cost approach to the problem. We would like to see the Army work within that framework. [Least cost approach in DoDD 4120.18], particularly with regard to recognizing the use of "hybrid metric" during the transition phase. It would be disruptive and needlessly expensive for the Army to insist on metric designs in those cases where the body of national standards and/or available materials do not yet support the effort.*[1] (RCA)

> *The Army will have to provide flexibility in the work statement to allow the selection of available metric standards and proven hardware. This approach will essentially provide a hybrid design during the initial transition period. Requirements which will demand utilization of national or international standards currently being created will provide the incentive for a broader cooperative national program and minimize overall costs to all involved....*[2] (Boeing Aerospace)

> *Army actions to facilitate transitions at Texas Instruments should consist of establishing metric standards which support the hybrid concept of design, utilizing industry accepted documents such as ASTM E-380, making their requirements known prior to design and qualification of equipment rather than imposing a metric requirement in later phases of procurement, and by not expecting a changeover without a business requirement to do so...*[3] (Texas Instruments)

> *Recognize and allow for the realities of procuring in a mixed metric/conventional environment. It is not currently cost effective to insist on completely metric systems unless they are so new in concept that they are started from clean paper...*[4] (Sperry-Vickers)

The practicality of the hybrid concept is well described by J. D. Garcia (Corporate Materials Management, Combustion Engineering, Inc.):

> *...let us address our metric product which is entering the inch world. Let us further assume that it is an all-world product. The product can be designed for production and usage out of the United States or, if produced in the United States where market research has said it would be detrimental to show SI metric notation, the design could be produced initially with dual dimensions and supplied to production with a drawing whose inch unit only would be exposed. In this manner, a nonvisible SI metric modular design can be introduced to users that are not yet ready for metric. Further, when the time is right for the metric product, all that need be done is to expose the metric notation and cover the inch notation.*
>
> *This is one approach to having the best of both worlds, realizing that some time in the future, as more metric mating components become available, the product will evolve further into an all-metric state.*[5]

Prescribing hard metric designs prematurely could have an adverse effect on product cost, serviceability, interchangeability, and reliability; hybridization provides an alternative. Caterpillar's remarks which follow can be put in perspective by recognizing that a new Caterpillar design typically includes 60% existing parts, and that Caterpillar products are long-lived.

> *...The change to metric measurement presents an opportunity for a company to review its present standards and consider adoption of a standard based on modules ideal to the metric system. However, the fact that a standard is based on metric modules is not reason enough to adopt the standard......The decision to adopt any new engineering standard of size must be based on product improvement or long term consideration, including cost, availability, and serviceability. The practice of adopting both language and metric engineering standards simultaneously is called "hard" conversion. To recommend or force this type of conversion would impose unnecessarily high costs.*[6]

Similarly, Texas Instruments notes:

> *It is necessary to maintain the spacing of electronic components on printed wiring boards with a soft conversion since any change affecting lead frame spacing, location of pads, connections, circuitry, etc. would require costly duplication of tooling and dual inventory. This would result in unwarranted cost to both the Army and Texas Instruments and could seriously affect the interchangeability and reliability of components in existing equipment.*[3]

While hybridization offers immediate, practical solutions to some metrication problems, the fact that it is a measure of expediency should not be overlooked.

> *...This [hybridization] approach will minimize the number of parts in inventories, minimize the number of different items to be qualified, and provide an early experience record for the new metric standards being created. It is believed that the hybrid design approach will allow a transition that will minimize the impact of operational readiness.*[2] (Boeing)

> *Recognize the fact that in some areas of design the product will be hybrid metric/customary for some period of time. However, demands by the Services for complete metric designs, along with similar demands from the private sector, will drastically reduce that time period.*[7] (IBM)

> *Our ultimate goal is to achieve total conversion to the international system of units as outlined in International Standard ISO 1000 and to internationally use and accept standards for materials and standard components which are readily available to each of our many plants. Our immediate plan, until such time as actions by the U. S. Government and/or U. S. industry make total conversion feasible, is to embark in an orderly fashion upon primarily soft conversion, which will give us some benefits in communication with our foreign plants and greatly ease the transition to international standards at some future date.*[6] (Caterpillar)

> *...On the other hand [arguing against hybridization], the longer conventional standards are insisted upon, the sooner new systems will be uneconomical to maintain.*[4] (Sperry Vickers)

The Australian Defense Forces have faced the issue of hybridization over the eight years that that nation has been converting to the SI measurement system. Some results from FI's study of foreign experience highlight elements of Australia's approach.

> *Metrication has impacted on all levels of the Defense establishment, but careful planning, organizing and training have obviated serious difficulty. It is realized that the long life of military equipment means that imperial unit equipment will be present in the armed forces of Australia for 20 to 30 years. Over time, materiel will become hybrid, i.e., combinations of imperial, soft and hard metric components, due to maintenance, repairs and refit activities.*
>
> *One of the few major problems which emerged from discussions with Australian Defense personnel concerned 105 mm tank ammunition. Following the requirement that all drawings be converted and equipment manufactured to metric dimensions, it was determined that the design of one type of ammunition fuze incorporated a critical time delay. To preclude requalification tests to certify that the metric-manufactured component had not changed this time delay, a decision was made to keep the parts of the fuze that determined the time delay in imperial dimensions.*
>
> *Military conversion was complicated by the need to ensure military readiness, limited military budgets, long lived inventory materiel and supply and maintenance problems. As with the civilian arm of the government and the industrial and consumer bases, the military has effectively introduced conversion measures. Hybrid materiel systems are accepted as being required. System life cycle costs and effectiveness are evaluated to determine exceptions from SI conversion or purchase.*[8]

Lessons Learned

1. Hybridization offers a practical, least-cost approach to metrication, especially early in the transition, i.e., before hard metric standards and materials become generally available.

2. Hybridization is an interim measure.

3. Hybridization tends to extend the transition period.

4. When planned for, hybridization can be an effective management strategy during metric conversion.

Problems/Opportunities for the Army

Adoption of hybrid materiel is a practical approach to metrication especially early in transition, but care must be exercised to ensure that hybridization is not the permanent approach. Also means of developing hybrid items, issuing RFPs which allow flexibility in degree of hybridization and for evaluating hybrid concepts must be developed.

HYBRIDIZATION NOTES

1. Letter from H. Kleinberg of RCA, October 7, 1977, in response to FI Survey of U. S. Industry.

2. Letter from A. H. Phillips of Boeing Aerospace, August 25, 1977, in response to FI Survey of U. S. Industry.

3. Letter from E. J. Tew of Texas Instruments, October 14, 1977, in response to FI Survey of U. S. Industry.

4. Letter from R. L. Hildebrandt of Sperry-Vickers, October 7, 1977, in response to FI Survey of U. S. Industry.

5. J. D. Garcia "Engineering Metrication" in Managing Metrication in Business and Industry, American National Metric Council (New York: Marcel Dekker, Inc., 1976), p. 40.

6. Frank Winters, Statement by Caterpillar Tractor Company before the Committee on Science and Astronautics, U. S. House of Representatives, in Metric Conversion in Engineering and Manufacturing (Washington, D. C.: ANMC, 1974).

7. Letter from L. J. Rankine of IBM, September 12, 1977, in response to FI Survey of U. S. Industry.

8. Forecasting International, Ltd., DARCOM Metrication Final Report Task A (Foreign Experience), Vol. 1 dated 8 November 1977.

4.5.3 Training

When an organization decides to convert to the metric system, one of the major issues that emerges is the training of personnel. Appropriate training of personnel is an essential element in achieving a successful transition, minimizing costs, and reducing or eliminating other problems. Thus training should be a significant element in overall metrication planning. As a number of corporate training experts have pointed out, metrication is a change and individuals have a tendency to resist changes. The most significant impact of metrication is psychological.

> *When the change is looked at objectively, it can be seen as primarily an exercise in education. Although scales and dials and read-outs and other measuring paraphernalia are the physical items to be changed, the real effect is in the minds of those who use them. This means that careful analysis must be made of human needs and this can only be done in the close contact of the individual business.*[1]

Metric Training Policies

Metric training policies will shape the magnitude of the training task and the funding required to carry it out. In surveying foreign and U. S. industrial experience several clear policies, which are being (or have been) pursued, are identifiable. These are:

1) Provide training only to those who need it;

2) Provide minimal training--that is, provide only what is needed to perform a particular job; and

3) Provide training just before it is needed for application because application will reinforce training.

Sixteen of the 26 companies that responded to FI's questionnaire on U. S. industrial metrication (Task B) demonstrate a concensus in applying these policies. Of the set of 26, the sixteen responding in concurrence with these policies all had some metric

training experience. General Motors, which is quite advanced in its conversion, provided the following statement:

> *The training organization of divisions and plants have available metric training modules which they use as they see fit. In general, they are following the practice of training only those people who need to know, only what they need to know on their job, and just before the need to use it. There have been no particular problems.*[2]

Similarly Xerox adheres to the following policy.

> *The training department must define the learner population and identify the actual metric training needs...A student [is given only that information] identified by the needs analysis data..... It is imperative that each student be trained just prior to his or her actual on-the-job need. Training too soon is almost as bad as training too late.*[3]

These policies tend to appear virtually universal if foreign practices and policies are examined. The Australian Metric Conversion Board, in recommending training policies, included the following:

> *Training should not take place until shortly before personnel are required to use metric terms.*
>
> *Personnel should not be taught any more than they need to know in order to do their jobs with the necessary degree of understanding.*[4]

Repco, Ltd. a major Australian corporation, indicates application of the following training policy in consonance with Metric Conversion Board recommendations:

> *There is a sound maxim governing the cost and applications of training, not exclusively a metrication concept, which says, 'do not train a person in skills he will not use.' Close adherence to this rule will hlep in the planning of personnel orientation and the type and timing of the instruction program adopted.*[1]

Planning Metric Training. The planning of metric training is critical to achieving successful metric conversion at minimum costs. In planning metric training, three key tasks have been identified by industrial experts. These tasks are:

1) Identify who needs training.
2) Identify what training is needed.
3) Identify when training will be required.

The role of this planning sequence for metric training is significant as the following comment by D. L. Venton of Xerox indicates:

> *The training department must now define the learner population and identify the actual metric training needs. A properly prepared needs analysis can do much to reduce training costs and the time required to complete the program.*[3]

The comment below, from IBM, indicates the range of training that may be required.

> *Some degree of metric education is considered mandatory in order to acquaint the employees with those aspects of our metric program with which they will be impacted. Those people who have already had metric education in school, i.e., high school or college, must also be trained since their early training was not SI, and they must become familiar with new style and usage of the SI system and the new units (pascals, newtons, etc.) which they should now be using.*[5]

The responses to FI's Survey of U. S. Industry indicate that the three-step approach to training planning mentioned above is common practice. Among the U. S. companies that followed this task sequence in planning training are Xerox, Chrysler, Sperry Vickers and Hewlett-Packard.

Various approaches to identifying groups of employees needing metric training have been applied. The Metric Conversion Board of Australia published the following guidelines to Australian industry:

The following starting points for determining categories of staff for training purposes are suggested.

- *Personnel requiring a full working knowledge of calculations appropriate, for instance, to the completion of an engineering certificate or higher qualification such as designers, research and development engineers, etc., should be able to handle conversion easily and should need only minimal instruction.*

- *Personnel requiring a working knowledge of simple calculations (including some involving derived units) for technical purposes, for example, supervisors, technicians, inspectors, etc. may require some specific training and will gain proficiency through on-the-job training of a repetitive nature.*

- *Personnel requiring simple basic knowledge for reference purposes, such as invoicing clerks, process workers, shorthand typists, print room assistants, etc., should not be overlooked and at least receive instruction in the meaning and correct use of those metric terms likely to be encountered in their normal activities.*

There may be a requirement for specific training programs for key personnel (e.g. supervisors) who will then return to their skills and train other members of the work force.[4]

Similarly, Chrysler stated:

> *Looking at the corporation as a whole, we realized we could divide our people into three basic groups, non-technical, technical and specialized skills. With this concept in mind, we designed three metric training programs.*[6]

In identifying the who and what of the training planning tasks, matrix analysis has been employed by several organizations in the U. S. and Australia. Xerox's approach presented below, was to identify the various elements of metric knowledge required for each job category. Repco, Limited, a large Australian corporation whose major businesses are the manufacture of automotive components and automotive services, prepared, at corporate level, a training manual

for use in each of its companies. In the manual is a matrix technique which can be used to identify training needs.

Xerox accomplished its assessment of training needs as follows:

(1) Questionnaire survey of job categories to determine key tasks of each job.

(2) Eliminate tasks not affected by metric practices or measurement.

(3) Detailed group interviews to refine analysis of metric training required by job category.

(4) Matrix analysis to determine commonality of training requirement across job categories.

The results of this analysis provide key inputs into designing metric training materials. The matrix analysis Xerox utilized is included as Figure 4-16.

Repco, Ltd. is a large Australian industrial enterprise composed of 100 registered companies. Training materials were prepared at corporate level and a matrix developed to assist companies in assessing their own training needs.

> *In order to determine needs we use a check sheet which is part of a Training Manual we have prepared. This lists all the principal job designations in a Company and the material in the Manual appropriate to the conversion program. Under each designation a check is made indicating that training could be necessary for that type of person in that particular area. We give each of our Companies a sample sheet for guidance and a blank form to fill out for themselves. In the Training Manual reference is made to material which is available for training, including a film strip with a programmed learning text which we have found very useful.*[1]

The matrix utilized by Repco companies is included in Figure 4-17.

FIGURE 4-16

XEROX MATRIX ANALYSIS OF TRAINING NEEDS

	Nontech Cler	Tech Cler	Draftsmen	Technicians	Engineers	Tech Mgmt	Mid Mgmt	Foremen/Supv	Machinists	T and D Makers	Qual Ctrl	Sales/Serv
Seven Base Units—Overview		●	●	●	●	●	●				●	●
Meter—Overview	●	●	●	●	●	●	●	●	●	●	●	●
Meter—In Depth			●	●	●	●		●	●	●	●	
Kilogram—Overview	●	●	●	●	●	●	●	●	●	●	●	●
Kilogram—In Depth			●	●	●	●					●	
Second—Overview	●	●	●	●	●	●	●	●	●	●	●	●
Ampere—Overview		●	●	●	●	●	●	●			●	●
Ampere—In Depth			●	●	●	●						
Kelvin—Overview			●	●	●	●	●				●	
Celsius—Overview	●	●	●	●	●	●	●	●	●	●	●	●
Celsius—In Depth			●	●	●	●					●	
Mole—Overview					●	●						
Candela—Overview					●	●						
Candela—In Depth					●							
Liter—Overview	●	●	●	●	●	●	●	●	●	●	●	●
Liter—In Depth			●	●	●	●					●	
Radian—Overview			●	●	●	●	●				●	
Radian—In Depth					●							
Steradian—Overview			●	●	●	●	●				●	
Steradian—In Depth					●							
Multiples and Submultiples—Overview	●	●	●	●	●	●	●	●	●	●	●	●
Common Usage—Multiples and Submultiples—Overview	●	●	●	●	●	●	●	●	●	●	●	●
Common Usage—Multiples and Submultiples—In Depth		●	●	●	●	●	●	●	●	●	●	
Common Derived Units—Overview		●	●	●	●	●	●	●			●	●
Common Derived Units—In Depth			●	●	●	●	●	●			●	
Derived Units—Overview			●	●	●	●					●	
Derived Units—In Depth					●	●						
Symbols—Overview		●	●	●	●	●	●	●			●	●
Symbols—In Depth		●	●	●	●	●					●	
Micrometer					●			●	●	●	●	
Vernier Caliper					●			●	●	●	●	
Dial Indicators								●	●	●	●	
Reading Engineering Drawings				●	●	●		●	●	●	●	

Source: Dave L. Venton, "Metrication Training" in ANMC, Managing Metrication in Business and Industry, 1976.

FIGURE 4-17

REPCO, LTD. (AUSTRALIA) MATRIX FOR SURVEY OF TRAINING REQUIREMENTS

METRIC TRAINING REQUIREMENTS SURVEY

Module	Section	Page
1	2	2

Module	Section	Description	Time	Mgr.	Sec'y.	Acc't.	Cost Acct.	Purch. Off.	EDP Mgr.	Pers. Mgr.	Pay Clerks	Stenog.	Typ.	Accts. Pay.		Chief Eng.	Degn. Eng.	Tool Eng.	Draftsmen	Qual. Eng.	Indus. Eng.	Mtce Eng.	Tool Makers	Lab-or'y.	Met'g. N T	Safety Off.
1	1	Company Policy																								
	2	Company Program																								
	3	Industry Program																								
	4	Customers' Programs																								
	5	Suppliers' Programs																								
2	6	SI Units – General																								
	7	Rules for Metric Expression																								
	8	Calculating – Units Gen.																								
	9	SI Units – Technical																								
	10	Calculating – Units Tech.																								
3	11	Standards – SAA etc.																								
	12	Standards – In company																								
4	13	Metric Drawing																								
	14	Rationalisation and Standardisation																								
5	15	Measuring Instruments – General																								
	16	Measuring Instruments – Special																								
	17	Tool and Gauge Control																								
6	18	Materials & Supplies – Purchasing																								
	19	– Issuing																								
	20	– Inventory Control																								
7	21	Customer Specifications																								
8	22	Part Numbering Systems																								
9	23	Machine Tools – New Equip.																								
	24	– Conversion																								
10	25	Office Equipment																								
	26	E.D.P.																								
	27	Stationery and Forms																								
11	28	Safety Considerations																								
12	29	References, Publications																								

FIGURE 4-17 (Continued)

Module	Section	Description	Works Mgr.	Prod. Eng	Prod. Cont.	Inspect	Plan Off.	Super.	F'man	L/Hs.	Oper.		Stores Super	S'man	Rec'g. Stores	Iss'g. Stores	Desp. Stores	Tool Stores	Stock Cnt'l.	Order Picker		Sales Mgr.	Sales Clerk	Reps	Career Staff	Advert.	Tech. Sales
1	1	Company Policy																									
	2	Company Program																									
	3	Industry Program																									
	4	Customers' Programs																									
	5	Suppliers' Programs																									
2	6	SI Units – General																									
	7	Rules for Metric Expression																									
	8	Calculating – Units Gen.																									
	9	SI Units – Technical																									
	10	Calculating – Units Tech.																									
3	11	Standards – SAA etc.																									
	12	Standards – In company																									
4	13	Metric Drawing																									
	14	Rationalisation and Standardisation																									
5	15	Measuring Instruments – General																									
	16	Measuring Instruments – Special																									
	17	Tool and Gauge Control																									
6	18	Materials & Supplies – Purchasing																									
	19	– Issuing																									
	20	– Inventory Control																									
7	21	Customer Specifications																									
8	22	Part Numbering Systems																									
9	23	Machine Tools – New Equip.																									
	24	– Conversion																									
10	25	Office Equipment																									
	26	E.D.P.																									
	27	Stationery and Forms																									
11	28	Safety Considerations																									
12	29	References, Publications																									

A similar approach could be used by the Army in identifying needs of its training programs at both headquarters and the field levels, and structuring training materials and activities.

General concensus among U. S. industry is that training should be given just before it is to be applied on the job. While this sounds relatively simple but can in fact be complex in the industrial environment, as the following comment from Xerox indicates:

> *If your company, like most companies, is planning to convert to metric only on new product programs, then you have a real training problem. Once everyone on your first metric product is trained, you will need to train new persons assigned to that program as they receive assignments. In addition, as other new products are started, the people on these new programs must also receive timely training in metric units. In addition, engineering and drafting personnel must be trained during the development phase of a new product, while manufacturing and sales personnel will require their training just prior to production or introduction of that same product. As you can see, metric training is not a one-time thing, but a continual effort that could conceivably last for years.*[3]

While this statement by Xerox indicates the potential difficulties in timing metric training, comments from some of the U. S. companies which are well into their conversions indicate that the problems are not insurmountable and are solvable through careful assessment of training needs and detailed planning. Comments from Sperry Vickers and Caterpillar are representative of U. S. companies with metric training experience. At Sperry Vickers:

> *Engineering design and development, manufacturing and inspection personnel have received training via company-designed training programs. The programs are presented when the training need arises, e.g., when a metric product is first introduced to a manufacturing group. There have been no significant problems amongst our own employees as metric products are introduced.*[7]

At Caterpillar:

In 1971 and early 1972, some of our Engineering personnel (draftsmen, checkers, and supervisors) were given about 45 minutes of indoctrination, including a review of SI and changes in drawing practices. We have found it unnecessary to provide this type training for engineers. They have some knowledge of the metric system and can learn the new SI without special training.

In the shop we have conducted group training sessions when a concentrated area was starting production of a metric model. Generally, however, when only one or two parts are introduced into an area, any required training is done by the supervisor or lead man or [an] individual basis. No significant problems have been encountered.[8]

Timing of Training

The discussion above focused on one aspect of timing metric training, i.e. with respect to application on the job. Another issue is raised regarding timing of training in relation to industry and nation conversion programs. The following indicates the Australian Metric Conversion Board's recommendation to Australian organizations regarding timing of metric training.

One policy appropriate for management to adopt is that training be coordinated with industry and general conversion programs for the following reasons:

- *Personnel will forget much of what they have been taught if the application of the knowledge is delayed for too long.*
- *Staff movements could result in unnecessary retraining if training is given too soon.*
- *The Metric Conversion Board envisages that the general public will be exposed to a wide range of publications and publicity and too early training could lead to unnecessary duplication.*
- *Appropriate data sheets, standards publications, trade literature and commercial conversion aids will become available as metric conversion proceeds. These could reduce or eliminate the need for some training.*

- *Personnel who face metric conversion late in the conversion program should not need as much training as those who are first to change.*
- *The experience gained in private life, by many people, could reduce or eliminate the need for some training.*[4]

U. S. companies which have implemented conversion plans have not had the benefit of a true national commitment to spur cooperation among companies within an industry in planning conversion and there has been no national conversion target date. However, where possible those companies (and the Army), can obtain advantages by utilizing public information campaigns to help build employee background in metrics. In view of Congressional confirmation of the President's nominees to the U. S. Metric Board, it is possible that public information on metrication will eventually increase--if the Board does as mandated in the Metric Conversion Act of 1975. With metric products in the grocery and liquor stores, the public is already receiving some metric education. As time goes on, the Army may find some training requirements reduced due to an increase in general public awareness. In planning metric training, the factors above should be considered.

The Role of Metric Awareness Programs

Most U.S. companies and foreign governments view metric awareness as an essential first step to all metrication activities including training. A low-keyed PR approach to metric awareness can be the key to gradually introducing the impending change and overcoming the natural psychological resistance to change. The role of a metric awareness program is not to provide any particular in-depth knowledge of the metric system; rather it is to make employees aware of the fact that metric conversion is coming and to demonstrate simple concepts of the metric system to alleviate fear and resistance. It is a promotional task.

Dave Venton of Xerox describes the role of a metric awareness program in some detail.

Once the commitment to "go metric" has been made and a tentative training schedule established, employees should be made aware of the impending change. An employee "metric awareness" program should be started. This will do much to reduce the normal resistance-to-change you can expect to encounter during the metric transition.

This metric awareness program need not be too structured and should take a minimum of time and effort. The idea is to inform your employees of what the company is doing and to arouse their curiosity concerning the change to metric. Articles concerning the metric changeover should be written and published in your company newspaper; metric wall charts can be posted conspicuously near bulletin boards; and metric movies can be rented and shown during lunch breaks; paper cups with metric slogans can be put in the coffee machines; displays of metric scales, instruments, etc., can be put in the lobby; and so forth. Use your imagination; at this point, metrication is a sales, rather than a training, job.[3]

Similarly, in developing its recommendations for metric training in Australia, the Metric Conversion Board noted that organizations should consider Metric Awareness Programs.

Increasing awareness of the change by attaching signs that illustrate various metric units to objects within the worker's environment. It should not be difficult or expensive to illustrate such things as length, mass, volume, velocity, power, density, pressure, temperature and the like in metric units. Attempts to introduce novelty into displays would enhance their value. Journals and house magazines could foster interest by reporting on novel displays.

The objective of the above is to assist personnel to think metric and, just as important in the early stages of conversion, to help to give them self-confidence in dealing with the new units. Displays should not be set up too far ahead of conversion programs, say about three months before the change.[4]

In the responses to FI's survey of U. S. industry, almost half of the companies responding indicated that metric awareness activities

are being carried out. The most frequently mentioned metric awareness activity is the publication of metric articles in company newsletters. Among the companies in this group are Boeing, Caterpillar, General Electric, FMC, Hewlett-Packard, McDonnell Douglas, Rockwell International, RCA, Texas Instruments and Westinghouse. The comments from RCA are typical of this group.

> *A series of "general awareness" articles has been prepared for use by the local plant newsletters. The intent of these articles is not training, but preparation for future developments...We also write and distribute a newsletter (approximately bi-monthly) for those in the company who should be kept aware of the national status. Distribution is about 150 people.*[9]

U. S. companies recognize the necessity of metric awareness program but the approach and level of activity vary from company to company, much in relation to their progress with and approach to metrication. Some companies such as GE publish articles in the house organs only infrequently. FMC's awareness program is somewhat more active.

> *In recent months various articles on metrication have appeared in various divisional house publications; and the last issue of FMC Progress, a publication distributed both internally and externally, contained an article on our metrication plans. We are trying to keep our metric PR as low keyed as possible.*[10]

Rockwell International, as another example, has given considerable thought to a metric awareness program and has developed a broad approach to the issue.

> *In the public relations area, a program is being formulated to help offset some of the potentially adverse psychological reactions by employees. It is important to start such a program early, to familiarize employees with the basic SI units, and to help assure them that it will not have a harmful effect on their jobs. Public relations personnel have begun this "metric awareness program" consisting of:*
>
> *News releases to the press, preparation of audio-visual presentations, company newspaper articles, posters and other visual material, charts, scales, and other handouts.*[11]

In Australia, the Army published an in-house newsletter called Metric Notes as part of its metric awareness program. The newsletter provides a periodic review of knowledge, activities and progress both within and outside of the Army.

With the growth of metric activities both here and abroad, more organizations tend to publish newsletters which provide an overview of national metric conversion plans and progress. In Australia, the Metric Conversion Board publishes a nationally available newsletter which can be used as an element of a corporate or organizational Metric Awareness Program. In the U. S. several such publications are commercially available. These include The Metric Reporter, published bi-weekly by the American National Metric Council (ANMC) and the U. S. Metric Association Newsletter published monthly by the U. S. Metric Association.

The concensus of opinion, generally based on experience, is that a Metric Awareness Program serves an essential role in assuring a smooth transition to metric usage. Its primary focus is to make employees cognizant of plans to change and to alleviate fears about the change. Psychological barriers to metrication are significant and a Metric Awareness Program is a workable, inexpensive approach to removing these barriers to a large extent.

Metric Training Methods and Materials

The one aspect of training where there is no consensus is on the methods and materials that are best for metric training. This is as it should be, because the design and content of metric training programs will vary widely among industries and among companies. Companies normally have to deal with personnel training regardless of metric conversion. Individual companies vary in organizational structure and assignment of training responsibility. In some companies, such as Chrysler, the training function is assumed by an independent part of the company. Chrysler plants' training programs are designed by the Chrysler Institute. In other companies, the bulk of training responsibility is at the division or plant level. The organizational pattern and assignment of training responsibility

will strongly affect the training methods and materials utilized in metric training. The background of the employers and the training needs will affect the methods employed as well as the level and depth of knowledge to be conveyed by the training. Corporate policies towards training also have a strong impact on training materials and methods.

Although the vast majority of U. S. companies adhere to the philosophy of teaching only what is needed to know to do a job, most companies' training programs included a broader range of knowledge. The following comment from Repco, Ltd. of Australia provides some insight into the rationale behind providing a broader training program.

> *In preparing [a metric training program] for use amongst our employees, we discovered two additional considerations. Firstly, it is wise to instruct a little wider than absolutely necessary in order to fill in the background, as it were. For example, an employee who only needs the concept of linear measurement for his particular job should also be introduced to area and volume to get the 'feel' for length in its proper context. Secondly, we believe that our social obligation requires that we give rudimentary instruction even to those who will not use any form of metric measurement directly in the work situation.*[1]

Some U. S. companies incorporate broad knowledge formally into their training programs. This has been Chrysler's approach.

> *Our training philosophy is basically very simple and in keeping with the general thought trend in industry. <u>Our training is tailor made for individual job classifications, not everyone will need the same information.</u> Personnel will be taught what is necessary to perform their job task. We believe it is also necessary to teach the employee "Nice to Know" information, along with "Need to Know" information. This is not to say we will teach everyone force in Newtons, and luminous intensity in Candela. But a little kitchen metrics can go a long way.*[6]

Other companies such as Hewlett-Packard and Boeing provide basic mandatory training and optional materials to those employees who want a broader background.

> *Hewlett-Packard's policy is to provide necessary training and also to offer the program to all its employees, i.e., teach what is required for the job but also make broader SI information available to those that want it.*[12]

Training methods employed by U. S. and foreign companies vary greatly. The vast majority note the use of a modular training program.

> *Hewlett-Packard has developed and implemented its own training program; commercially available programs did not meet their needs. The program is modular so that it can be tailored to particular situation/needs. The program has been video taped for use on Hewlett-Packard's closed circuit TV system.*[12]

At General Motors:

> *The training organizations of divisions and plants have available metric training modules which they use as they see fit.*[2]

The companies that use modular training units emphasize the flexibility it allows in putting together appropriate training programs to fit specific needs of different division and job classifications within the company.

IBM, which is one of the most advanced companies in its metric conversion, highlights the complexities involved in designing its training program which is modular.

> *When we [IBM] began our metric changeover, there were no metric training programs available, that we could find, which covered the SI metric system. Furthermore, there were no programs covering the ISO standards which we were adopting. As a result, we had to develop our own education programs...... Our program was designed on a modular basis covering basic awareness through the SI measurement system and the ISO standards which we were adopting. Being modular, the program can be adapted to the needs of the various functions, i.e., the entire program for Manufacturing Engineers; awareness only for the majority of employees; the SI style and usage for secretaries, etc.*

Early in the development of our education program we felt that familiarity with the metric system must be carried beyond the use of the metric measurements for dimensioning and calculations in order for our employees to be able to think metric. What appeared to be lacking were textbooks, reference manuals, etc., and this required the development of training modules for manufacturing engineers, design engineers, quality engineers, inspection and manufacturing employees. These people required not only the SI system training but also knowledge of the specific ISO standards which are being adopted, such as the standards for screw threads, surface finish, the limits and fits system and others.

Also included in the program was metric information on process and equipment capability, tool specifications, machining calculations and other such information which today is available in customary dimensions but not in metric. We also stressed the use of expanded tolerances which would permit the use of inch or metric materials or tools to produce the required metric dimension. Some of the innovations which we included to accomplish this were "hands-on" experience with measuring tools and gauges, total familiarity with the new ISO standards and handout materials for reference on the job.[5]

Many methods or techniques are available for application to metric training. Examination of U. S. and foreign practice indicates a wide range of techniques being used. Methods include on-the-job training, classroom instruction, programmed instruction (or directed learning), and use of training aids designed in-house, and/or commercially available. Many U. S. companies including Chrysler and IBM emphasize the importance of "hands on" experience as part of training. Some companies use several different methods of conveying metric information to the individuals to be trained, depending upon the depth and breadth of knowledge required and metric experience of the individual to be trained. As RCA noted "we expect our engineers and scientists to be largely self-educating".[9] Training demands for these individuals could simply be provision of appropriate reading material. The following discussion from Honeywell demonstrates the concept of use of numerous methods and materials within the same organization.

Our own material was developed in the absence of any suitable commercially-available aids. As time progresses, of course, metric training materials will continue to become more available and can minimize much internal company effort on such material.

Our training material and methods encompass several media. We have slides, transparencies, video tape, booklets, and utilize various commercially-available aids such as metre sticks, centimetre tapes and rules, Celsius thermometers, gram scales, 1/2-litre measuring cups, millilitre measuring spoons, etc. Models of some key metric denominators such as centimetre and decimetre cubes are used. We also have developed a slide rule covering convenient conversions between SI and other popularly used units.[13]

Descriptions of Chrysler's and IBM's training programs are contained in Annex H to provide specific examples of metric training, programs in operation in the U. S. Australian corporations tend to favor programmed learning or what they call directed learning, using workbooks and similar materials. Annex H contains a statement extracted from ICI Australia, Ltd. regarding its policy and design of metric training programs.

The conclusion that can be drawn from examining industry practice is that there is no "one best way" to conduct training. The methods employed will depend on the general corporate training philosophy, locating of training responsibility, training experience and practices, needs of personnel and a variety of other factors. Companies tend to use those methods that are habitually used in meeting other corporate or division training needs.

Commercial Training Aids

In the early 1970s, there were very few commercially available metric training aids and most companies had no choice but to develop their own programs and materials from start to finish. Today, with metrication picking up speed, more commercial products are available. Thus it is possible to alleviate the need for developing a complete package of metric training materials in companies and organizations

just beginning their conversion. Of the 40 companies responding to the ANMC Aerospace Sector Survey of Metric Training, nine indicated that they used commercially available training aids as part of their metric training program.[14]

Regarding development of its metric training program, RCA provided the following insights.

> *We have determined that it would not be cost-effective to develop our own training courses, even though we have excellent facilities to do so. We have, instead, reviewed many of the commercially available courses, and have developed a list of those recommended for operating units who may need them.*[9]

Since more training aids are commercially available today, it is possible that some of these materials may be appropriate to U. S. Army needs. The use of commercially available training materials could reduce the magnitude of the task of preparing metric training materials in-house.

Lessons Learned

1. Commitment of the organization to metric conversion will enhance the ability to provide least cost training.

2. Clear training policies must be established. These will shape the cost and magnitude of the training exercise. The following training policies appear to be universal and should be evaluated in the context of Army needs:

    a) Provide training only to those who need it;

    b) Provide minimal training--that is, provide only what is needed to perform a particular job; and

c) Provide training just before it is needed for application because application will reinforce training.

3. Thorough and thoughtful planning of training is essential to ensuring the provision of metric training at minimum cost. Key tasks in planning metric training are:

   a) Identify who needs training;

   b) Identify what training is needed;

   c) Identify when training will be required.

4. Training programs should be timed to take advantage of national public awareness campaigns and exposure to metrics as consumers--where possible. This may lessen Army training burdens.

5. The normal human reaction to change is resistance. Well thoughtout Metric Awareness Programs, which are generally not expensive, can alleviate much of this resistance and fear of the unknown.

6. There is no "right" or "best" training methods or set of materials. Training methods and materials used must be geared to the organizational structure, location of training responsibilities, and training needs.

7. A modular, multi-media approach is frequently employed by U. S. companies and may be appropriate to Army needs.

8. Many commercial aids to metric training and metric awareness programs are available. Some of these might be useful to the Army and would reduce the magnitude of materials to be prepared in-house.

Problems/Opportunities for the Army

While technical personnel will probably require only minimal training, unskilled individuals may present difficult training problems to the Army. Commercially available modular training programs may be useful to the Army for some parts of its training program--but the problem cited above may require specifially designed programs to suit the background and educational levels of the individuals to be trained.

TRAINING NOTES

1. E. Y. Barnes, "Conversion of a Diverse Engineering Establishment" in Metrication: The Australian Experience, Proceedings of the North American-Australia Metric Conference, April, 1975, p. 49.

2. Letter from Everett L. Baugh of General Motors Corporation, August 26, 1977, in response to FI Survey of U. S. Industry.

3. Dave L. Venton, "Metrication Training," in American National Metric Council, Managing Metrication in Business and Industry, 1976, p. 80.

4. Australian Metric Conversion Board, Industrial Training for Metric Conversion in Australia, 1971.

5. Letter from L. J. Rankine of IBM Corporation, Spetember 12, 1977, in response to FI Survey of U. S. Industry.

6. Letter from John T. Benedict of Chrysler Corporation, August 31, 1977, in response to FI Survey of U. S. Industry.

7. Letter from R. L. Hildebrandt of Sperry Vickers, October 7, 1977, in response to FI Survey of U. S. Industry.

8. Letter from J. G. Langenstein of Caterpillar, August 29, 1977, in response to FI Survey of U. S. Industry.

9. Letter from Harry Kleinberg of RCA Corporation, October 7, 1977, in response to FI Survey of U. S. Industry.

10. Letter from M. E. Smith of FMC Corporation, September 8, 1977, in response to FI Survey of U. S. Industry.

11. Letter from E. B. Ash of Rockwell International, September 12, 1977, in response to FI Survey of U. S. Industry.

12. Summary of telephone conversation with John Bogren of Hewlett-Packard, October 3, 1977, responding to FI Survey of U. S. Industry.

13. L. W. Foster, "Case History, Honeywell, Inc., Inc." in Metrication--Managing the Industrial Transition, ASTM STP 574, American Society for Testing and Materials, 1975.

14. ANMC Aerospace Sector, Metric Training Survey: Summary of Results, November 1976.

4.5.4 Usage of SI Units, Other Units, and Preferred Multiples

There are two potentially troublesome aspects of the International System of Units (SI) which bear consideration in the conversion to the metric system. These are perpetuation of units accepted for limited use, and the use of inappropriate multiples of SI units. The advantages which can through the use of a common measurement language will be lost in proportion to departures from the common language.

SI is defined and described in the following authoritative references:

ISO 1000 - SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units

ASTM E 380/IEEE Std 268/ANSI Z210.1 - Metric Practice

76 FR 36414 - Metric System of Measurement (U. S. Department of Commerce Notice in the Federal Register of December 10, 1976

The importance of proper use of SI is succinctly stated in ANSI Z210.1:

> *To protect the new system from degradation, and to cooperate with knowledgeable people all over the world who are recommending good unit use, this standard strongly urges the use of SI, plus a very limited group of non-SI units, the need for which is strong and is widely endorsed. Accordingly, while this standard agrees with the major standards in the world on the description of SI, it differs from some in the list of additional units. While all the units recommended in this standard are also recommended in the national documents of other countries and in ISO 1000...some of the units recognized in these documents are not preferred for USA use, since proper suitable SI units are available for the quantities involved.*
>
> *1.3 It is hoped that an understanding of the system and its characteristics, and careful use according to this standard, will help to avoid the degradation that has occurred in all older measurement systems.*[1]

Use of SI base, supplementary, and derived units presents few problems. (The -er/-re spelling of meter represents a controversy of minor significance.) Other units authorized by the references (termed "Units in Use with SI"), such as the day, degree Celsius, and liter, also create few problems. The third category ("Units Accepted for Limited Use") has proved troublesome abroad, and has the potential to do so in the United States. This category includes the kilowatthour (energy), bar (pressure), and rad (absorbed dose). Each of the units in this category should eventually be replaced by the appropriate SI unit. Sweden, a case in point, experienced great reluctance in replacing the bar in favor of the pascal. In response to the FI survey of U.S. industries, two of the 26 respondents made specific mention of the use of SI.

From FMC:

> *...the Army should adhere to the SI System, as interpreted by the Secretary of Commerce, with no deviations to permit the smoothest possible transition.*[2]

and from Hewlett-Packard (in a paraphrase):

> *Keep SI "pure"; use no US-only terms or symbols. Hewlett-Packard deplores the use of "L" (for liter) and the -er spelling of metre and litre.*[3]

SI admits of 16 multiples (prefixes) of each unit. The references provide general rules for prefix selection, but usage has established, and will continue to establish, the selection for appropriate circumstances. The centimeter, for instance, is accepted as the appropriate multiple of the meter for clothing sizes, but not for textiles, for which the rule of three (micrometer, millimeter, meter) is preferred. South Africa, as an example, initially prescribed the use of the centimeter for textiles; this inhibited the introduction of preferred multiples in its textile industry. To avoid similar problems, the Army should adopt the preferred metric multiples used by the various industrial sectors.

Lessons Learned

1. Adhere as closely as possible to authorized SI units; deprecate the use of units accepted for limited use.

2. In the selection of preferred multiples of SI units, adhere to published guidelines and relevant industrial practice.

Problems for DoD/Army

1. The Army, like any converting organization, can expect to experience a reluctance, on the part of affected users, to abandon familiar units in favor of unfamiliar SI units, especially where the difference is perceived to be small. The bar, for instance is "almost" metric (10 mb = 1 kPa); continued use of the bar, however, degrades SI and destroys its coherence.

2. Establishment by the Army of preferred multiples of SI units which are inconsistent with industrial practice could prove disruptive and confusing. The probability of such occurrences would be minimized by maintaining awareness of metrication progress and plans in the various industrial sectors.

NOTES

1. ANSI Z210.1-1976, American National Standards Institute, August 19, 1976, Foreward and Page 7.

2. Letter from M. E. Smith of FMC, September 8, 1977, in response to FI Survey of U. S. Industry.

3. Telephone conversation with John Bogren of Hewlett-Packard, October 3, 1977, in response to FI Survey of U. S. Industry.

4.5.5 Automated Data Processing

Metrication will impose changes on Automatic Data Processing (ADP) systems. The symbols, punctuation, and rules of usage of SI are more precisely defined than those for customary units. Unauthorized departures from standard SI practice, or the use of undefined SI symbols, will create major problems in interpreting measurement-sensitive information; these problems will be compounded if the information is conveyed internationally. Since so much information is prepared and conveyed by ADP systems, and since most ADP systems lack the ability to print lower case and Greek letters, the impact of metrication on ADP systems deserves the attention of managment information system and ADP users as well as programmers.

ISO 1000 is the standard international reference on SI usage (see also Section 4.5.4). ISO/D/S 2955 (Representations for SI and Other Units to be Used in Systems with Limited Character Sets) provides explicit supplementary guidance applicable to ADP systems. Computer programmers will require a thorough understanding of SI and ISO 2955 in order to program intelligible printouts. For instance, the number 21,000 (customary) becomes 21 000 (SI); the separating space must be dealt with by the programmer. (However, numbers on a nominal scale, such as part numbers, do not require a separating space; e.g., part number 12345 is correctly stated).

The use of SI may, in addition, require some increase in field sizes and storage capacities. For instance, where a 3-digit field was sufficient to accommodate a distance in miles, 4 digits may be required to accommodate the same distance in kilometers.

The major impacts of metrication on ADP, considering that the measurement system in use is <u>either</u> customary or SI, have been identified above. The transition period, when ADP systems must deal with <u>both</u> customary and SI units, will produce problems and considerations of its own, albeit they will be temporary. The discussion which follows draws heavily on the insights presented by Thomas G. Cross of IBM at the ANMC's Fourth Annual Conference on April 5, 1978.

An ADP input or output form which is to accommodate both customary and SI data will require more fields, larger fields, or both. An additional field, to permit the use of unit of measure codes, has proved useful. For instance, Code 1 might indicate the use of customary units, Code 2, SI. Storage requirements will also increase. The number of transactions, hence program size, will increase with the addition of conversion algorithms.

Conversion algorithms deserve the attention of the ADP user (to assure accuracy of the output) and the programmer (to maximize computing efficiency). The following example illustrates the point. Suppose an individual is to be reimbursed for traveling 750 miles at \$0.10 per mile.

In customary units, the claim is:

750 mi x \$0.10/mi = \$75.00

And, similarly, in SI units the claim is:

750 mi x 1.609 344 km/mi x \$0.10/mi x
0.621 371 1 mi/km = \$75.00

But this requires two large (i.e., precise) conversion factors. From a programming point of view, less precise conversion factors are desirable. However, anomalies can result by using less precise conversion factors.

Precision to 2 significant digits:

750 mi x 1.6 km/mi x \$0.10/mi
x 0.62 mi/km = \$74.40

Precision to 3 significant digits:

750 mi x 1.61 km/mi x \$0.10/mi
x 0.621 mi/km = \$74.99

Better results can be obtained by minimizing the number of conversion factors used:

750 mi x 1.6 km/mi x \$0.10/mi
x (1/1.6) mi/km = \$75.00

Rounding rules to fit the circumstances must be consistently applied when converting from customary to SI, or vice versa. Two methods are described in ANSI Z210.1.[1] Computer program packages for making the conversions efficiently are available from the National Bureau of Standards.[2] The NBS package contains 3 programs developed by Caterpillar Tractor Company and General Motors Corporation. The programs are written in American National Standard FORTRAN and are essentially machine-independent; they have been tested on the UNIVAC 1108, PDP-10, and IBM 370 systems.

Comparisons between information in SI units and historical data in customary units must recognize the effects of rounding errors. For any single conversion the error may be small, but the results of accumulating a long series of conversions may be worthless. Where comparisons must be made, accuracy in the results will be improved by minimizing the number of conversions.

In the numerical control of machines, identification codes have proved useful in sorting out the measurements associated with inputs and outputs. The following table is illustrative:

Identification Code	Measurement	
	Input	Output
0	Inch	Inch
1	Inch	mm
2	mm	Inch
3	mm	mm

Lessons Learned

1. Computer programmers will require thorough understanding of metric usage and, specifically, ISO 2955; this usually implies a training requirement.

2. SI-only ADP systems may require additional storage; input and output formats may require larger field sizes.

3. ADP problems will be greatest during the transition, when concurrent use of customary and SI units can create problems with respect to field sizes, storage capacity, conversion algorithms, and rounding errors.

4. Machine-independent, tested computer conversion programs are available.

5. Identification codes have proved useful in reducing confusion regarding data values and their associated units, for both input/output formats and for numerical machine control.

Problems for DoD/Army

ADP is widely used in the Department of Defense. Chaos could result unless effective planning for ADP system software changeover is undertaken on a timely basis. It should be noted, however, that not all ADP systems will have to be rendered dual-capable.

NOTES

1. ANSI Z210.1-1976, ASTM E 380-76, IEEE Std 268-1976, Metric Practice, August 19, 1976.

2. Computer Program Package for Metric Conversion, COM-75-10960, Reference Manual, National Bureau of Standards, July 1975.

4.6 Summary

This section contains a list of the major lessons learned. They are listed by category and topic, in sequence as the discussion appeared in the earlier section.

THE METRIC ENVIRONMENT

<u>Voluntary Conversion</u>

1. Metrication is inevitable. International and some national evidence point to voluntary conversion becoming more binding with passage of time.

2. There are some U. S. sectors where a voluntary consensus has already resulted in regulated changes to metric.

3. Evidence from abroad indicates an acceleration of voluntary metric conversion actions, after national metric boards are established, during the first several years.

<u>Legal Issues</u>

1. There are legal barriers to metrication outside of Army control and which will not impact on the Army directly. These legal barriers may inhibit industrial conversion and thus the Army should recognize that the barriers exist.

2. Procurement regulations may need revision if they prohibit or inhibit metric conversion.

3. Incorporation of metric considerations in the DARs appears to be a cost-effective approach to making procurement regulations conducive to metric conversion.

<u>The Role of Public Attitudes</u>

1. Public attitudes toward metrication can strongly affect success of national metric conversion. Early involvement of the public in metrication has been an element of successful foreign conversion.

2. Irrational fears about metrication can be minimized by public education programs and will diminish as experience with metrics increases.

3. Mechanisms will have to be considered to prevent unfair pricing and deceptive practices during transition.

<u>International Considerations</u>

1. International factors are a driving force behind U. S. industrial metrication.

2. The Army, due to U. S. industry's conversion, will eventually have to metricate to avoid costly procurement.

3. The Army is subject to pressures in the international arena such as RSI and foreign military sales which will lead to Army metrication.

<u>U. S. Labor</u>

1. Legitimate labor concerns about metrication do not present unsolvable problems.

2. Labor attitudes are not likely to inhibit U. S. metrication because of the importance of export markets and the jobs created thereby.

<u>Army's Ability to Influence Industry and the Federal Government</u>

1. DoD/Army lacks the economic leverage necessary to either force or prevent industrial conversion to metric.

2. As a valued customer, DoD/Army can influence (help or hinder) industrial metrication.

3. Metrication planning and actions in concert with industry will be in the interest of DoD/Army.

4. DoD/Army can influence (but not force or prevent) metric conversion within the Federal government.

5. Metrication planning and actions in concert with other elements of the Federal government will be in the interest of DoD/Army.

THE PHILOSOPHY OF CONVERSION

Commitment

1. Highest level commitment in any organization (national, corporate or government) is essential to an orderly, least cost metric conversion.

2. A high level commitment is characterized by:

   a) Formal announcement that metrication will occur.

   b) Formation of a Metric Advisory Group.

   c) Appointment of a Metric Coordinator.

3. Currently the U. S. Army does not exhibit characteristics of high level commitment to metrication.

Costs

1. Manage metrication effectively on the principle of least cost using a systems approach.

2. Initiate metrication with new designs.

3. Recognize the need for hybridization.

4. Monitor industrial metrication progress as a means for minimizing or avoiding costs.

5. Limit metric development and production demands to industrial metric capabilities.

6. Make metric requirements in contracts clear but allow contractors flexibility in meeting them.

7. With few exceptions, let metrication costs lie where they fall.

8. Modify budgets, funds allocation, and procurement procedures as necessary to minimize net Army metrication costs.

9. Capitalize on offsetting benefits wherever practicable; e.g., standards development.

10. Consider life cycle costs.

11. Where urgency is not a factor, replace capital equipment with dual or SI-only capable equipment on normal replacement schedules; similarly, revise publications and manuals when scheduled for normal review.

12. Where cost-effective, consider modification kits to provide dual or SI-only machine capability as an alternative to premature replacement.

Metrication Benefits, Advantages and Opportunities

1. Metric benefits are generally long term rather than immediate.

2. Some metrication benefits are intrinsic, such as simpler calculations and improved communication.

3. Metrication offers a rare opportunity to evaluate current practices, create rational ones, and abandon obsolete methods.

4. Recognition and exploitation of opportunities afforded by metrication is prerequisite to realizing the benefits, particularly tangible benefits, of the conversion.

THE CONVERSION PROCESS

Mode of Conversion

1. An evolutionary Army metric transition will be the least costly and most effective.

2. Metrication of all Army activities concurrently, at rates suited to each, will be most effective.

3. Realistic and flexible timetables for significant metrication milestones can serve as useful Army planning and management tools.

4. Good planning of the metric conversion activities will minimize the impact of metrication on the Army user.

Management and Organization

1. Foreign and U. S. industry experience indicates metrication requires only a small organization, with a top level review committee, to coordinate, expedite and inform.

2. Top level review committees should include members from all elements of the organization.

3. A low-key, business-as-usual attitude, treating metrication as a new technology or new procedure, works well in U. S. industry especially for companies used to dealing with new technologies on a frequent basis.

4. Day-to-day dealings with metrication requires decentralized operations and decision-making functions.

5. The major functions of top management are:

   o to provide a continuing and firm commitment to metrication;

   o to coordinate metrication activities;

   o to ensure communications among internal and external groups.

6. Those who must implement conversion should be the planners.

7. Ad hoc and/or informal working groups are frequently used in corporations to deal with metrication problems and issues.

Coordination and Communication

1. Effective coordination and communication are essential to assuring a least-cost metric conversion.

2. Coordination is a multi-faceted problem of maintaining active informal two-way communications with outside grou-s, with other DoD agencies, among major Army commands and staff agencies, and with subordinate units.

3. There is a need to establish the identify, cohesiveness and sense of purpose among individuals concerned with metrication. There is a need to mesh the metrication information and coordination network with the decision-making network.

MAJOR DETAILS

Standards and Specifications

1. The national effort to accommodate the workload on standards and specifications resulting from metrication is complex and involves many industrial and governmental organizations and various national institutions.

2. The DoD/Army complex can not undertake the metric conversion of standards and specifications on independently or on its own schedule.

3. Effort towards conversion of standards is progressing at a slow but accelerating pace through the voluntary standards-writing mechanisms.

4. Resources must be provided for DoD/Army participation in the conversion effort if the maximum to be gained from the effort is to be realized.

5. Soft conversion of Federal and DoD standards and specifications, in conjunction with their normal review, is a sound metrication practice which requires minimal additional effort.

6. Army participation in appropriate national and international standards-writing bodies will help assure that U. S. Army requirements are considered in the development of new hard SI standards, and will thereby help reduce the number of military standards which must be written and maintained.

Hybridization

1. Hybridization offers a practical, least-cost approach to metrication, especially early in the transition, i.e., before hard metric standards and materials become generally available.

2. Hybridization is an interim measure.

3. Hybridization tends to extend the transition period.

4. When planned for, hybridization can be an effective management strategy during metric conversion.

Training

1. Commitment of the organization to metric conversion will enhance the ability to provide least cost training.

2. Clear training policies must be established. These will shape the cost and magnitude of the training exercise. The following training policies appear to be universal and should be evaluated in the context of Army needs:

   a) Provide training only to those who need it;

   b) Provide minimal training--that is, provide only what is needed to perform a particular job; and

   c) Provide training just before it is needed for application because application will reinforce training.

3. Thorough and thoughtful planning of training is essential to ensuring the provision of metric training at minimum cost. Key tasks in planning metric training are:

   a) Identify who needs training;

   b) Identify what training is needed;

   c) Identify when training will be required.

4. Training programs should be timed to take advantage of national public awareness campaigns and exposure to metrics as consumers--where possible. This may lessen Army training burdens.

5. The normal human reaction to change is resistance. Well thoughtout Metric Awareness Programs, which are generally not expensive, can alleviate much of this resistance and fear of the unknown.

6. There is no "right" or "best" training methods or set of materials. Training methods and materials used must be geared to the organizational structure, location of training responsibilities, and training needs.

7. A modular, multi-media approach is frequently employed by U. S. companies and may be appropriate to Army needs.

8. Many commercial aids to metric training and metric awareness programs are available. Some of these might be useful to the Army and would reduce the magnitude of materials to be prepared in-house.

Usage of SI Units, Other Units and Preferred Multiples

1. Adhere as closely as possible to authorized SI units; deprecate the use of units accepted for limited use.

2. In the selection of preferred multiples of SI units, adhere to published guidelines and relevant industrial practice.

Automated Data Processing

1. Computer programmers will require thorough understanding of metric usage and, specifically, ISO 2955; this usually implies a training requirement.

2. SI-only ADP systems may require additional storage; input and output formats may require larger field sizes.

3. ADP problems will be greatest during the transition, when concurrent use of customary and SI units can create problems with respect to field sizes, storage capacity, conversion algorithms, and rounding errors.

4. Machine-independent, tested computer conversion programs are available.

5. Identification codes have proved useful in reducing confusion regarding data values and their associated units, for both input/output formats and for numerical machine control.

CHAPTER 5

STRATEGY OPTIONS--DEVELOPMENT AND EVALUATION

The discussion in this chapter represents an analysis of the strategy options available to the Army in achieving metrication. The range of possible Army actions is first explored and approximately bounded by the constraints imposed by DoD Directive 4120.18. The broad economic and political environment in which Army metrication is embedded is then analyzed. On the basis of this information, five tentative Army metrication strategy options, which cover the region of viable Army actions, are stated, explored, and tested. Finally, based on a comparison of those strategies which survive the testing process, a recommended Army metrication strategy is produced.

5.1 Conceptual Framework for Strategy Development

In a situation with no constraints, the Army has an infinite number of strategy options open to it, in theory. These options represent a continuum ranging, on one end, from championing the perpetuation of the customary measurement system to leading the world metrication movement on the other. Obviously, these global extremes are ludicrous; most of the world is already metric, and with the last bastion crumbling, the customary system is indefensible. DoD Directive 4120.18 broadly establishes the realm of Army interest. It provides fairly definitive boundaries on the range of viable Army metrication strategies. Under this mandate, the Army cannot ignore metrication and do nothing; it "will consider the use of the metric system..." At the other extreme, the Army cannot lead the changeover; "Generally, it is recognized that industry will take the lead ..." It remains, then, to frame and describe a set of strategy options which lie between the two boundaries last mentioned. Within

this range there are, however, broad economic and political considerations which shape the environment within which to find an optimal Army metrication strategy.

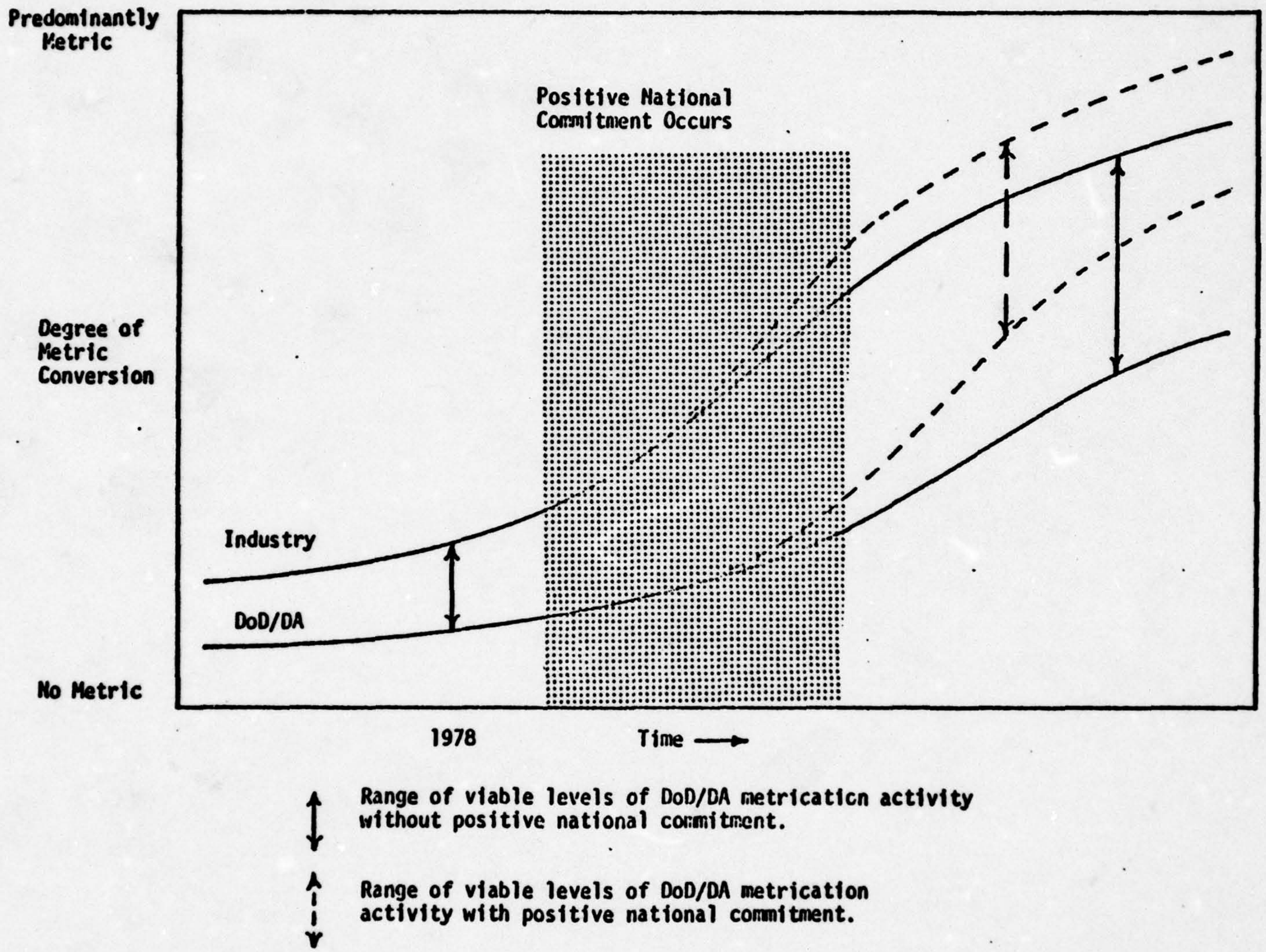
Taking economic considerations first, it should be clear from the material presented in Chapters 3 and 4 that industry is the driving force in U. S. metrication; industry is far ahead of the other national sectors and will continue to metricate. Economic forces will drive industry to seek the attainment of all-metric capability at some date in the future. Metric conversion of U. S. industry is inevitable. World economics dictate the conversion in order to sell in the world market and to compete effectively. The Army, as a significant customer of industry, will have to accept and accommodate the industrial changeover. There will come a day (and it may not be in the distant future) when major Army suppliers will be unwilling or unable to produce Army products in customary units at competitive prices. This condition, or the anticipation of it, will eventually lead the Army to convert also. The issue then becomes one of recognizing the inevitability of the change and getting on with it.

Broad political considerations--a positive national commitment to metrication expressed by the President and/or the Congress--must also be dealt with in assessing the metrication environment. In a strict sense, PL 94-168 is permissive in nature. Judging by the years that it took to get an acceptable metrication bill through Congress, and the nearly unanimous vote on PL 94-168, it does not appear that the precepts of "increasing use of the metric system" or the voluntary nature of the conversion (See Section 4.2.1) will be abandoned under any circumstances. Nevertheless, a leadership role for government is not precluded under the law. If a positive national commitment were to occur or develop, what would be the impact on the Army?

Figure 5-1 provides a perspective on this question. Postulating that metrication progress will follow an S-shaped growth pattern (which typically describes the introduction of new technologies

FIGURE 5-1

CONCEPTUAL FRAMEWORK FOR STRATEGY DEVELOPMENT



and products rather well), a pair of curves results, one for industry, one for DoD/DA. The latter curve can be thought of as a minimum metrication level; as pointed out above, the Army, to some extent, will have no choice but to accept industrial metrication. Furthermore, the industry curve can be considered a maximum metrication level for the Army. In other words, the range of viable Army metrication levels at any time lies between the two curves, as shown.

If a positive national commitment were to occur at some time (in the hatched region indicated in Figure 5-1), the rate of metrication could be expected to accelerate. Preserving the increasing use/voluntary precepts, the accelerations shown by dashed lines would most likely result from government actions to remove legal and regulatory barriers to metrication, rather than from direct inducements to metricate. In other words, industry would continue to metricate at an economical, but increased, rate. Within Federal departments and agencies (including the Army), official commitment and support, ccupled with directives (or changes to directives) which facilitate metrication, could accelerate conversion at a rate somewhat faster than industry's.

It may be inferred from Figure 5-1 that the impact of a positive national commitment will diminish with time, i.e., the acceleration induced on industry metrication by such a commitment, as industry approaches a predominantly metric state, would be smaller than that induced at any earlier date. The effect of national commitment on DoD/DA would be analogous, although the DoD/DA metrication level might be considerably lower than industry's. The potential impact of a future national commitment on the Army would be further diminished because the measures and methods which the Army will have to employ to accommodate industrial conversion would then be available to deal with an accelerated conversion rate. It follows, therefore, that a positive national commitment, unless it occurs immediately, will not have a truly significant effect on the U. S. Army. The probability that a positive political commitment to

metrics will occur within the next year is very low. A commitment in the years after 1978 is likely to have less and less real impact as industry conversion accelerates under economic stimuli. Finally, even if a target date for U. S. metric conversion were established at some time in the future, through a positive national commitment, the impact on the Army would not be significant because any such date would most likely be set in consonance with current industry plans, i.e., on economic grounds.

To summarize, Army metrication strategy options must take into account not only the boundaries set by DoDD 4120.18, but also the broad economic and political metrication environment. Industrial metrication is driven by economic stimuli; metric conversion is inevitable, even in the current passive political environment. If a positive national commitment to metrication were to occur, its impact on the Army, in terms of having to respond in new or different ways, would be minimal, unless such a commitment were to occur in the very near future, an unlikely prospect.

With the foregoing background information in mind, it is now possible to develop a set of Army metrication strategy options. If alternatives are to be presented, each strategy option framed must be discrete and sufficiently different from the others to be identifiable. Since we are dealing with a continuum, however, the strategy options will necessarily represent segments of the continuum, rather than points on it, and they may overlap to some extent.

Five tentative strategy options are listed in Figure 5-2. These five options appear to fit in the region of viable action shown graphically in Figure 5-3. Each tentative strategy option will be described and tested in the next section.

FIGURE 5-2

TENTATIVE ARMY METRICATION STRATEGY OPTIONS

1. Convert to metric only as prescribed by higher authority or when conversion results in a demonstrably lower cost, measured in terms of dollars and workload.

2. Augment current Army metrication activities as necessary to increase metric usage in a coordinated fashion and with minimum disruption of other efforts.

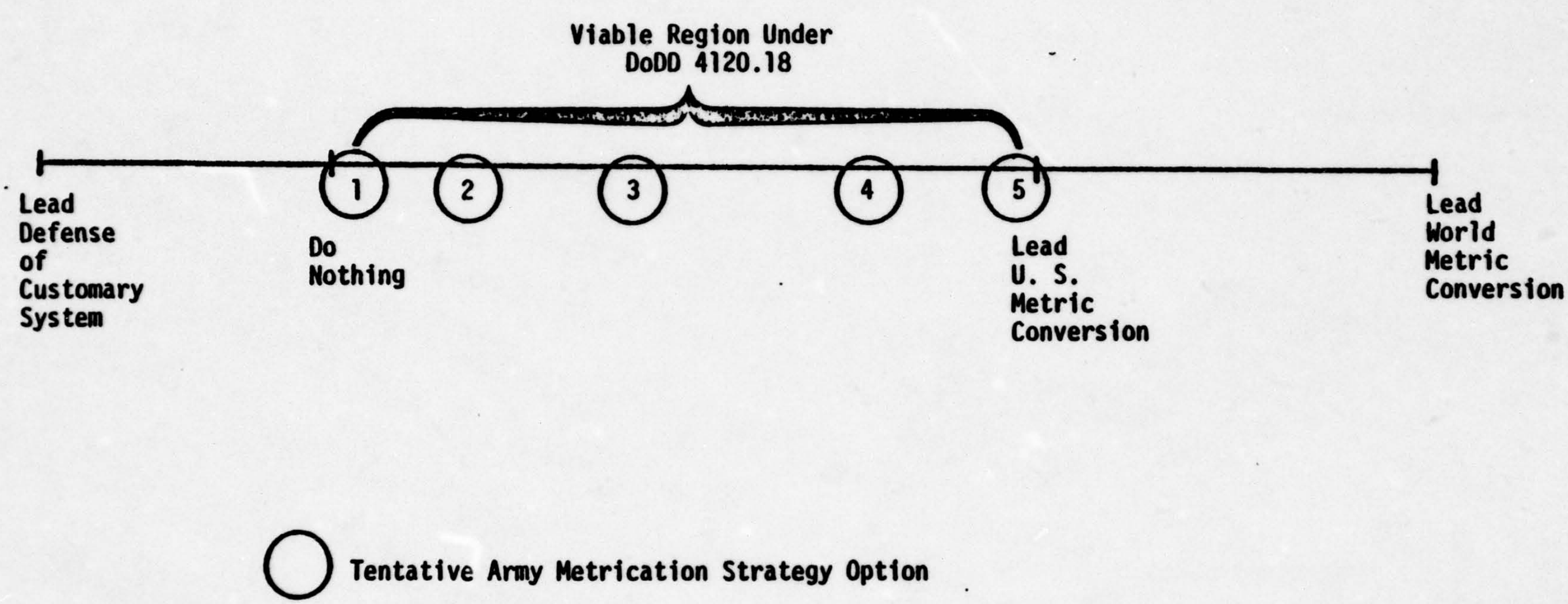
3. Adopt metrics as practicable in all Army activities and prepare for an accelerated metric transition.

4. Take all reasonable initiatives to realize the potential benefits of metrication and promote national metrication where advantageous to the Army.

5. Take all necessary measures to rapidly convert the Army to metrics; assume a strongly progressive role by adopting metrics in concert with the leading edge of industrial metrication, and exert a continuing positive influence to accelerate industrial conversion as necessary to meet Army needs.

FIGURE 5-3

RANGE OF ARMY METRICATION STRATEGY OPTIONS



5.2 Conceptual Descriptions and Testing of Strategy Options

5.2.1 General

In this section, the concept of each strategy option is explored in the context of information developed in Chapters 2, 3, and 4. The purpose of the concept is to describe and explain the intrinsic purpose and implications of the strategy, and to examine the effects of these implications in sufficient depth to permit the strategy to be tested.

Each strategy option is tested for suitability, feasibility, and acceptability by eliciting a judgment in response to the following questions:

- <u>Suitability</u>: Will successful pursuit of this strategy accomplish the Army's metrication mission?
- <u>Feasibility</u>: Is pursuit of this strategy within the Army's capability?
- <u>Acceptability:</u> By pursuing this strategy, are the anticipated results worth the estimated costs (expressed in any appropriate terms)?

These tests are performed in the order given. Failure of any test obviates the need for further testing of that strategy, e.g., if it is found that a particular strategy will not accomplish the mission, it is pointless to ascertain whether the means are available to implement it. A strategy which fails any test is rejected from further consideration. It is possible, however, that development and testing of the concepts will suggest additional strategy options, or that a rejected strategy can be salvaged by combining it with another strategy. Any strategies thus formed are then treated as new strategies and subjected to the development and testing process.

If only one strategy option survives the testing process, that option becomes the recommended strategy on which further planning

will be based. If two or more strategy options survive the testing process, they are subjected to additional analysis to provide a basis for comparison. By identifying and weighing the advantages and disadvantages of each option, a reasoned judgment of the best option becomes possible, again leading to the recommended strategy.

STRATEGY OPTION 1

Convert to metric only as prescribed by higher authority or when conversion results in a demonstrably lower cost, measured in terms of dollars and workload.

Concept

Under this strategy, Army metric conversion would proceed slowly, at least early in the national transition, and be marked predominantly by new metric designs specified by OSD/DA. Metric conversion, where not prescribed by OSD/DA, would also proceed conservatively because of the stringent cost criterion imposed. A slow conversion would necessarily be evolutionary in nature. This would tend to minimize disruption of operations and short-term costs. Metrication benefits, where recognized, would have to be tangible and relatively short-term in order to overbalance the conversion cost criterion. Becuase of the ad hoc nature of the conversion, costs would be absorbed by the converting project. For the same reason, conversion planning, outside the system/project acquisition decision-making process, could be undertaken largely as a collateral duty of relatively low priority. Under the impetus of the metric projects in process or contemplated, the need for metric standards (both military and industrial) would be recognized. This would generate a workload in the writing or revising of MILSTDs, as well as a need to coordinate with industrial standards-writing bodies. Coordination activity, at relatively low priority, would also be required within the Army, and within DoD. Some coordination with industry would also be required, especially by those PMs and Commands involved with metric projects. However, a broad and general awareness of the state of industrial metrication and industry's metric capabilities would not be required.

This strategy is reactive in nature. Metric action is taken only as a last resort, on a case-by-case basis. The Army does not keep pace with industrial metrication; it merely queries particular companies or industries from time to time as current or contemplated

projects require. The explicit cost consciousness and lack of a systematic approach to Army metrication virtually precludes realization of metrication benefits and the proper consideration of long term effects. As a result, development of metric systems/products in support of standardization with NATO and other Allies can only proceed at a snail's pace. If this strategy were to be pursued over the implicitly long transition, the total cost would necessarily be high; if for any reason national metrication should accelerate, the Army would very likely be required to undertake an expensive crash metrication program.

In summary, this strategy does not allow the acceptance of industry conversion by keeping pace. It is costly over the long run and it does not support standardization with NATO Allies to any significant extent. It is concluded that this strategy fails to satisfy the Army's metrication mission; it is therefore rejected as unsuitable.

STRATEGY OPTION 2

Augment current Army metrication activities as necessary to increase metric usage in a coordinated fashion and with minimum disruption of other efforts.

Concept

Under this strategy, the Army would consider metric conversion on a case-by-case basis as further metrication guidance is received from OSD, and where metrication could be accommodated without unduly interfering with ongoing programs. The need for coordination, as metric activity increases, is recognized. This strategy, reflecting a strict interpretation of PL 94-168 and DoDD 4120.18, supports the increasing use of metrics, but makes no predictions as to whether or when metric conversion will be completed.

Continuing current practice, metric consideration would be given predominantly (but not exclusively) to new designs, particularly to those systems earmarked for Allied use. Questions of standards and costs would immediately arise. Standards development would require a major Army effort. This additional effort (a cost) would have to compete with other MILSTD-writing demands, with the result that metrics could be abandoned for the project. Since the approach to metrication is essentially case-by-case, the Army (at least initially) would probably have less interest in participating in the development of industrial standards of broad applicability than in developing MILSTDs for a particular project. However, if the number of metric projects in a given sector (e.g., automotive) were to grow, the benefits attaching to suitable industrial standards of wide applicability (i.e., supplanting new MILSTDs) could lead to significant Army participation in appropriate industrial standards-writing bodies. Contact with industry would be required for each candidate metric project in order to determine the current

and/or projected industrial metric capabilities and costs. Dissemination of this and other metrication information to other involved Commands would be required. The volume of metrication information would increase as the number of metric projects and involved industrial sectors increased. Budget allocations or changes to procurement regulations to facilitate an overall metrication program would probably not be seriously considered until or unless rather extensive metrication activity had developed. Initially each project would have to bear its own metrication costs (or else revert to customary units); later, if a coordinated metrication program evolved, however, action could be taken to ameliorate some of these problems. To minimize disruption of operations, each new system, and its associated logistics support elements (training, maintenance, storage, etc.), would have to be dealt with separately. If the number of metric systems/products fielded became large there would be an impact on the ILS system including a need to standardize and rationalize repair parts and tools across systems. Requirements for metric coordination (with industry and within the Army) incident to this strategy would emerge as the number of metric projects increased. They would include intra-Army elements at all levels concerned with development of metric projects; intra-DoD coordination would also be required where systems/products for intra-services use were involved. Most metric coordination would be undertaken in conjunction with related responsibilities of those normally involved in the projects. As the number and diversity of metric projects increased, however, a need for broader coordination would develop in order to facilitate the exchange of metric information and provide or recommend metrication policy. This metrication organization could also be largely ad hoc, but a few dedicated spaces would probably be required.

This strategy is a conservative approach to metrication which addresses the principal elements of the Army's metrication mission. Consideration of metrication of new designs, and of all other areas of Army activity, is encouraged, paced by industrial metric capabilities, but with strong emphasis on minimizing costs and

disruption of operations. It is concluded that this strategy would satisfy the Army's metrication mission; it is therefore suitable.

The cost and effort implicit in this strategy are tied, at least initially, to particular projects/products which are determined to be metric. Coordination with industry, and with other involved Army elements, would be undertaken predominantly by PMs as part of their normal responsibilities. If the tempo of metric activity were to accelerate (as a result of undertaking many metric projects, or if a positive national metric commitment became a reality), costs associated with broader Army participation in industrial standards development, metrication planning and coordination, and integration of metrics into the Army logistics infrastructure would climb disproportionately because the piecemeal approach to metrication taken by this strategy does not lay an effective foundation for a rapid and general metric expansion. In the initial period, the costs implicit in this strategy are minimal and clearly within the Army's capability. In a period of accelerated metrication, the costs, in terms of dollars and the disruption of operations, would be great, but still within the Army's capability to absorb on an emergency basis; this strategy is therefore feasible.

Strategy 2 represents a minimum suitable means of complying with DoDD 4120.18. Because of the heavy emphasis on minimizing costs and disruption of operations, short-term considerations would prevail in the consideration of metric projects and products. As a result, metrication would proceed slowly, and very few benefits would be realized. Pursued indefinitely, this strategy would guarantee the longest, and therefore costliest, possible transition. If for any reason the pace of metrication were to accelerate, the Army would find itself reacting to one crisis after another since the strategy does not support an overall metrication plan. Costs (however measured), which on a case-by-case basis may have been minimized, would quickly exceed benefits; the concurrent disruption of operations would require a major remedial effort.

In summary, the benefits attainable under this strategy cannot be great under any circumstances; if metrication activity accelerates for any reason, they will virtually disappear. Costs (measured in any terms) would range from low to enormous, based on the same premises. Thus described, the expected results are not worth the anticipated costs. Therefore Strategy 2 is not acceptable.

STRATEGY OPTION 3

Adopt metrics as practicable in all Army activities and prepare for an accelerated metric transition.

Concept

While there may currently be little to indicate an impending metric impact of significance to the Army, this strategy anticipates that such an impact will occur, whether created over time by progressive industrial conversion, or by establishment of a positive national commitment to metrication, or both. This strategy is two-fold: start capitalizing on metrication now, and be prepared for a major transition effort whenever it comes.

Under this strategy the Army would actively explore the feasibility of new metric designs, and of metric conversion of any other facet of its activities where advantage can be gained. Coordination within the Army (DARCOM/MSCs) and with industry would be required to assess industry's metric capabilities, associated costs, and the potential benefits of conversion. To cover a wide range of Army interests (rather than a few isolated projects), an extensive network would be required to gather and disseminate metrication information. Consideration of new metric designs would immediately generate a need to develop new metric standards (industrial and military). Because of common procedures, standards, and equipment, the Army would be required to coordinate its metrication activities with other DoD Components. The "as practicable" approach taken by this strategy implies a balanced consideration of the costs incident to a particular metric undertaking (gained, for instance, through knowledge of industry's metric capability), and consideration of the disruptive effect of metrication on operations. Where only a few metric projects are involved, the most disruptive aspects imposed by metrics would properly be dealt with in Integrated Logistic Support (ILS) planning for the new system. Where the number of new metric systems is large, however, and particularly

where non-system metrication is contemplated (to convert all speedometers and road signs to metrics, for instance), a broader level of coordination would be required. A metrication organization would be necessary for this purpose, and to establish or recommend metrication policy.

This strategy represents a reasonable approach to accomplishment of the Army's metrication mission. Pursuit of this strategy would ultimately satisfy the principal objectives of the Army's metric conversion mission: transition in harmony with industry, standardization with Allies, and consideration of metrication in all activities. Accomplishment of lower level mission elements is not precluded by this strategy. It therefore satisfies the suitability test.

Costs incident to this strategy fall principally in the areas of coordination, standards development, and logistics. Allocation of resources to meet these costs and priorities of effort will require a DA level commitment to this strategy.

Coordination necessary to keep generally abreast of industrial and governmental metrication would require a significant effort on the part of all elements of the Army. In most cases this could be accomplished in the course of normal associations related to the products and services of interest; metric information would be just one more element to be dealt with. Army participation in appropriate industry and/or government metrication planning forums, at the DARCOM and MSC levels, is indicated. This would require allocation of time and funds for personnel designated on a collateral duty basis; this would ensure Army planning and action is responsive to an accelerating pace of U. S. industrial metric conversion and permit timely and meaningful response to Allied standardization matters.

A means to centrally manage the gathering and disseminating of metric information, and to formulate/recommend metrication policy, would be required at each Command level. Ad hoc committees (composed of senior staff members) would probably suffice in most

cases, at least early in the transition (i.e., until a major metrication effort became evident). A small, full-time metrication staff would probably be required, however, at the DA level or at a level acting as a surrogate for DA. In addition to the duties cited above, this staff would coordinate with its counterparts in DoD and with OSD.

The standards-writing effort under this strategy would be considerable, not only to support metric project/product developments undertaken, but also to prepare for the major transition effort envisaged. Active participation in industrial, Federal, ISO and NATO standards-writing bodies would be necessary as a means of minimizing the number of new or revised MILSTDs to be written and certified. Time and funds to support this Army activity would be required. An increase in the number of militarily acceptable industrial standards notwithstanding, there would be an accelerating workload increase associated with MILSTD development that will require planning effort to properly cope with the problem(s).

Coordination necessary for metric project/product development and acquisition would be essentially the same as for non-metric projects and products, assuming the standards-writing problem has been dealt with properly. Since coordination would be performed by those normally involved in the development and acquisition process, the additional effort/cost imposed by metrics would be minimal in preparation of necessary documentation. If on the other hand Army does not plan properly to respond to the accelerating rate of U. S. industrial conversion, then specifying items in the inch-pound measurement system will result in premium priced materiel and will potentially escalate the cost of future systems/items.

The logistics impact of this strategy would be felt, for new designs, in all aspects of the ILS system. The most significant impacts would be on maintenance and supply; test, measurement and diagnostic equipment (TMDE); and training. However, the increasing application of metrics, implied in this strategy, should allow the

the associated costs and effort to be planned and programmed for minimal adverse effect. Necessary metric TMDE, for instance, could be acquired, not solely to support a particular project, but as part of a programmed conversion of this equipment. Similarly, training programs could be developed for application to more than the project that generated the training requirement. Minimum cost options are likewise possible for other aspects of ILS by properly planning for the accelerating metric state of the nation's industrial complex.

To summarize, most of the cost and effort necessary to support this strategy is assumed incrementally by those normally involved in system acquisition, and by DARCOM and MSCs where general industry and government coordination is required. The standards-writing and ILS workloads would increase and a small dedicated metrication staff and funds for travel associated with standards-writing and metrication coordination and planning are necessary. The costs associated with these requirements do not appear to be beyond the Army's capability to absorb in any case; moreover, costs are self-limited by the "as practicable" approach embraced by this strategy. It is concluded, therefore, that Strategy 3 meets the feasibility test.

Under this strategy, there is a high probability that at least some of the benefits of metrication will be realized: diminishing the long term costs of supporting inch equipment in a metric world by every new metric system introduced; actively seeking metrication opportunities as a means for improving methods or capabilities. The comprehensive coordination network will allow planning and decision-making to proceed from a position of knowledge to the end that the Army would be better prepared to accept an accelerated transition, thereby obviating a costly emergency metrication program. These benefits appear to heavily outweigh the costs outlined in the previous paragraph. It is therefore concluded that this strategy is acceptable.

STRATEGY OPTION 4

Take all reasonable initiatives to realize the potential benefits of metrication and promote national metrication where advantageous to the Army.

Concept

Under this strategy, the Army would concentrate on identifying and capturing the benefits of metrication, and on influencing the national transition to the Army's advantage. The focus would be on the long term benefits, such as cost avoidance associated with a reasonably short transition, and standardization with NATO and other Allies, while actively exploiting opportunities for future metric payoffs by rationalizing functional procedures and methods, as well as product varieties, as occasions arise. The rate at which the Army would increase its metric usage would be determined by the minimum (life cycle) cost and minimum disruption of operations criteria. Within these constraints the Army metrication program would be characterized by variable transition rates and flexible timetables for the conversion of each area or sector of its activities.

Underlying this strategy is a philosophy of purposeful transition, i.e., the metrication process would evolve with a goal in mind, rather than in haphazard fashion. Unequivocal commitment to metrication at the DA level would be required to make such a philosophy operative. This strategy would require the Army to not only keep pace with metrication in industry and the Federal government, but also to participate and influence metrication developments to its own advantage. Army influence cannot dominate either industry or government interests, but it can retard or advance those interests. In order to exert its influence, the Army would be required to participate actively in appropriate standards-writing bodies and metrication planning forums. It would also exchange information with industry concerning metric system acquisition plans, metric production capability, availability of metric materials, parts, and

tools, etc. In this way, unreasonable metric product demands by the Army (with their premium costs) could be avoided, and industry could lay realistic metrication plans based on the needs and desires of its Army customer.

Similar close coordination would be required among the Army and other DoD Components with regard to military standards development, common supplies, and metrication program planning in general. In a broader context (especially if a national metrication program were initiated), an effective interface among DoD and the other Federal agencies (including the Interagency Committee on Metric Policy and, as appropriate, the U. S. Metric Board) would also be required for essentially the same purposes.

This strategy would require effective metrication planning and coordination within the Army. A high volume of metrication information would need to be exchanged within the Army (DARCOM and MSCs) and between the Army and DoD Components, as well as between the Army and its industrial suppliers, standards-writing, and metrication planning groups. Those responsible for implementation would perform metric planning functions essential to their operations on an ad hoc basis. An informal metrication organization, with a few dedicated staff spaces, would be necessary to assure the flow of metric information and to provide metrication policy guidance. By these means Army planning could keep pace with metrication progress and anticipate future developments in industry and government, should the rate of metrication accelerate in either of these areas.

The Army, under this strategy, would truly keep pace with industrial metrication, and would be in a position to influence to its own advantage the direction, rate, and timing of the transition. The constraints to minimize cost and disruption of operations would act to prevent too rapid a transition. The benefits of metrication would be sought and exploited across the full spectrum of Army activities as metrication progressed; standardization with NATO would be more vigorously supported. Pursuit of this strategy would clearly accomplish the Army's metrication mission; it is therefore suitable.

Much of the cost of implementing this strategy is measured in terms of the planning and coordination effort required. Although participation in standards-writing bodies, industrial metrication planning forums, etc. would be undertaken by those whose normal responsibilities lie in the areas of interest, the magnitude of the task would very quickly grow. The active participation (even leadership) envisaged under this strategy would very likely result in a significant workload for many of the Army participants, leaving less time for normal responsibilities. Standards development, in particular, would place a heavy workload demand on the Army which would probably require additional staffing at the expense of other areas. Tangible official support of coordinating, planning, and standards-development activities, in the form of additional funds, would also be required; again at the expense of other areas.

Management of this aggressive approach would require several dedicated (paid) spaces, augmenting the ad hoc membership of the Army's metrication organization, to develop and coordinate the implementation of Army metrication policy. Possibly, a program management structure might be indicated to cope with a rapid tempo of metrication activity.

Apart from the personnel costs cited, there are other costs associated with this approach. The accelerated pace itself could give the appearance of being expensive: other things being equal, life cycle costing would favor metric projects and products although early in the transition metric acquisition costs would be higher. As the rate of metric acquisitions increases, so would metric training requirements, with their associated costs (which would rise, but not without limit).

To summarize, the workload and dollar costs implicit in this strategy are considerable. The faster the Army's metric transition, the higher they would be. The pace of the transition (hence the Army costs), however, tends to be limited by industrial progress which, even with the Army acting as a change agent, will only

proceed at a speed which is economical for industry. With this upper limit in place, this strategy, although expensive, appears to be within the Army's capability. This strategy is therefore feasible. It would, however, require a major reallocation of priorities and funds.

Long term gains may fully justify the costs associated with this strategy. It is probable, however, that these costs will be highest early in the transition, as is frequently the case with life-cycle costing. Added to this would be the cost of rapidly establishing a base, or infrastructure, to support this aggressive strategy (for coordination and standards-development, for instance). Furthermore, the costs of promoting industrial conversion early in the transition could, like pump priming, far exceed those which might be necessary to achieve the same effect once industry had progressed farther in the conversion process. There is, in other words, a cost difference between fostering a major change and an incremental one. Taken together, these high initial costs would be difficult to program and would have to compete, in annual budget cycles, with existing demands for resources.

On balance, adoption of this strategy, at least from the beginning of the Army transition, appears to be premature; even admitting that total (long run) benefits would exceed total costs, the initial costs could very well be judged too high. There is a further risk: if this strategy were adopted, pursued for a few years, and then abandoned as too expensive, the resulting disorder and loss of momentum could only damage the metrication program and incur further costs. It is therefore concluded that magnitude and time distribution of expected costs make this strategy unacceptable.

STRATEGY OPTION 5

Take all necessary measures to rapidly convert the Army to metrics; assume a strongly progressive role by adopting metrics in concert with the leading edge of industrial metrication, and exert a continuing positive influence to accelerate industrial conversion as necessary to meet Army needs.

Concept

In pursuing this strategy, the thrust would be to get on with the job, to hasten the day when the benefits of metrication (such as standardization with NATO and other Allies) can become realities. The rapid transition could disrupt on-going Army operations, hence detailed and highly coordinated planning would be required, but a short transition would also tend to reduce total metrication costs by getting more metric equipment into the field sooner.

Within the Army an effective organization would be required to assure an interchange of metric information. Particular efforts would be necessary to provide timely, relevant, and reliable information to PMs and other decision-makers responsible for metricating materiel. The high tempo of Army conversion would require a number of full-time spaces in the metrication organization at the DARCOM/MSC levels. The need to develop hard metric standards would produce a major workload and increase funding needs. Early in the transition hard standards would not be available, necessitating the use of soft-converted standards. With the need for metric standards so pressing, it is not likely that rationalization of standards would be thorough. It is also unlikely that industrial standards-writing would be developed fast enough, thereby necessitating development of MILSTDs and/or adoption of NATO/ISO standards. The interface with industry would be difficult. While companies which were already converting to metrics would probably welcome more metric business, company responses to metric orders beyond their capabilities would necessarily take the form of premium costs. The Army would have to entice and persuade industry to keep up by all

possible means. Metric materials, parts, and tools would not be generally available (at least early in the transition). This would require a coordinated and wide ranging Army effort to find suppliers and keep them apprised of Army needs. Prime contractor capability to respond to metric system emphasis will be governed by the ability of small businesses to react to metric demands. Private industry can afford to select cooperative small business subcontractors on commercial business activities, but, Federal law opens the need for all small business organizations to bid as subcontractors on government funded procurements. Expression of metric characteristics could open charges of unfair practice on the part of government and big business. It could very well result in increased reliance on foreign suppliers, where permitted under the Buy American Act. Interagency, and particularly intra-DoD, coordination of a high order would be required because of the effect of the Army's accelerated metrication program on common procedures and supplies.

This strategy goes beyond the intent, if not the letter, of the mission derived from DoDD 4120.18. A rapid transition will tend to reduce metrication costs and to realize some tangible benefits of metrication. However, where the rate of transition is too fast, as it is here, costs will again rise (for increased staffing, metric product premiums, etc.). Under this strategy, costs cannot be minimal. The greatest failing, however, lies in the rate of Army transition compared to the industrial rate. While some industries and companies could probably accommodate a rapid Army transition, the majority could not. Under this strategy, the Army does not keep pace with industry (as required); it is industry which must match the Army's progress. It is concluded, therefore, that this Army strategy is unsuitable.

5.2.2 New Tentative Strategy Options

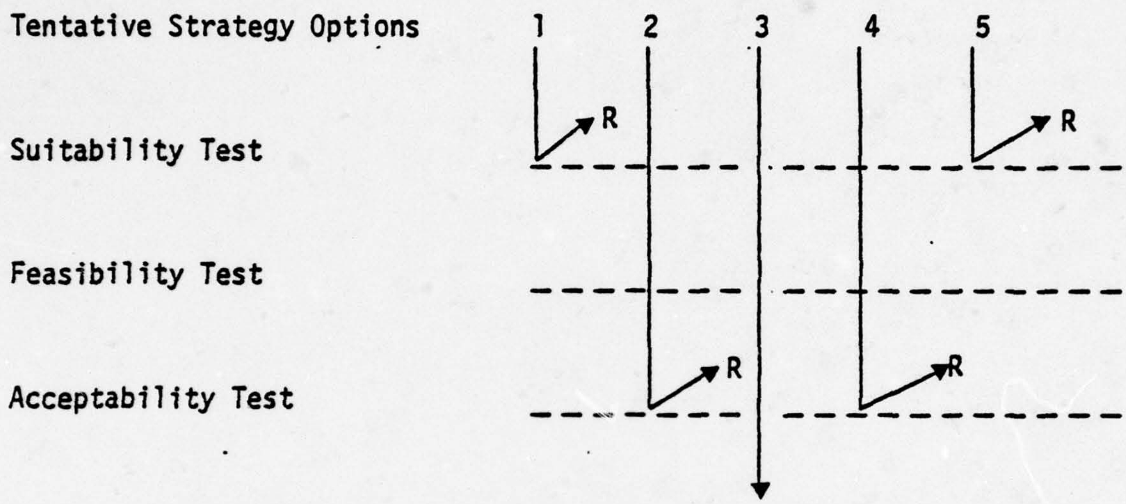
Up to this point all five of the Tentative Strategy Options originally framed have been explored and tested. As may be seen graphically in Figure 5-4, only one strategy option survived the testing process; each of the other four contained some fatal flaw as an expression of a viable Army metrication strategy.

Tentative Strategy Option 4, although inadequate by itself, embodies an attractive feature not contained in any other option: recognition of the Army's ability to influence metrication in industry and government, and the selective use of this ability when advantageous to the Army. The following new Tentative Strategy Option is therefore stated. Exploration and testing of this strategy option are undertaken on the succeeding pages.

6. Capitalize on metric conversion by adopting metrics as practicable in all Army activities, preparing for an accelerated metric transition, and, when appropriate, promoting national metrication where advantageous to the Army.

FIGURE 5-4

INTERIM SUMMARY OF STRATEGY TESTS



<u>Note:</u>

R = Reject

STRATEGY OPTION 6

Capitalize on metric conversion by adopting metrics as practicable in all Army activities, preparing for an accelerated metric transition, and, when appropriate, promoting national metrication where advantageous to the Army.

Concept

This strategy represents a flexible, forward-looking approach to metrication. The purpose is to take maximum advantage of metrication benefits throughout the transition while minimizing disruption of operations and keeping costs at minimum levels, having due regard for both current and life cycle cost considerations. Implementation of this strategy would begin by considering the adoption of metrics in any area of Army activity as opportunities arise, particularly when U. S. industry appears capable of supporting a given metric effort with little or no cost burden, and for new designs which foster Allied standardization. Concurrently, the infrastructure necessary to support systematic Army conversion to metrics would be developed. This infrastructure would also enable the Army to respond effectively to an accelerated national transition triggered by external economic or political events. Moreover, this systematic approach would enable the Army to promote industrial and governmental metrication to its own advantage in appropriate circumstances.

Under this strategy, projects involving new metric designs would be undertaken as necessary to further Allied standardization (complementing the Rationalization, Standardization and Interoperability (RSI) Program), and in other areas of Army activity as opportunities and advantages become evident based on progress of U. S. industrial metrication. In all cases, least-cost approaches would be taken by introducing new metric capital equipment only in conjunction with normal replacement. Coordination with industries involved in the projects would be immediately required. Coordination with all industries which produce goods and services for the Army, including participation in metrication

planning forums, would also be necessary in order to recognize metrication opportunities and developments which would affect Army system acquisition planning and procurement decisions. This coordination effort would be accomplished principally by those whose normal responsibilities include the necessary contacts (e.g., PMs for projects, MSCs and DARCOM for more general purposes). In addition to obtaining metrication planning and status information, coordination would be required for metric standards development. The writing, rationalization, and certification of standards would become a major undertaking for the Army (as it has for industry). Effective Army participation in the development of industrial, ISO, and NATO standards could result in a reduced requirement for MILSTDs.

As metrication activity increased, so would the need to manage the gathering and dissemination of metric information among the many involved Army elements, and between the Army and other DoD Components. Army interests in Federal metrication could be represented by the DoD member of the Interagency Committee on Metric Policy. Based on U. S. industrial and foreign experience, most of this activity could be effectively accomplished by ad hoc committees composed of senior staff personnel at the DARCOM and MSC levels. A small dedicated staff at the DA organizational level would probably be required to oversee the metrication program and develop or recommend metrication policy.

The Army's aim under this conversion strategy would be to realize to the fullest the advantages and benefits offered by metrication, first by seizing opportunities that are discovered, and second by participating in, and influencing to its own advantage, metrication developments in industry and government. Army influence cannot dominate either industry or government interests, but it can advance or retard those interests. By establishing the means to permit the Army to respond to industrial and governmental metrication progress, as outlined above, the Army would be in a position to exert its influence where most advantageous. This effort could be expected

to carry a cost with it. For instance, if Armed Services Procurement Regulations (or DARs) represent an impediment to realizing some Army metrication benefit, then it might be advantageous to allocate some Army resources to their revision. Similarly, long-term benefits to be realized by enhancing defense-industry preparedness or defense production readiness might warrant the absorption of incremental metrication costs in specific cases. Actions such as this go beyond keeping Army metrication passively in tune with the environment. Positive and sustained commitment to metrication at the DA level would be required under Strategy 6, particularly if initiatives like the foregoing were to be taken.

This strategy would enable the Army to accept industrial metrication on a minimum cost, minimum disruption of operations basis. It would also foster standardization with NATO and other Allies by emphasizing metrication of new designs. Metrication in all Army activities would be encouraged where advantages could be realized. Strategy 6 is concluded to be suitable.

The resources needed to implement this strategy are time (i.e., workload), funds, and Command commitment to metrication. Coordination with industry, and within the Army, represents an incremental workload increase shared by many people. Position allocations for the small dedicated metrication staff would be required. Metric standards-writing and certification costs, over the whole transition, will be significant, but under this strategy the rate of standards development would be governed by economic constraints. Even where the Army chose to bear some of the cost associated with metrication, those decisions would be taken on the basis of cost-benefit (recognizing that the benefits might be long term). A burden on the Army at high level is the requirement of positive and sustained metrication implicit in this strategy. Commitment is essential to assure that metrics are properly considered at key decision points in the acquisition process (e.g., ASARC and In-Process Reviews), and to authorize, guide, and support the resource allocations necessitated by metrication.

In summary, most coordination/participation costs would be minimal, being borne incrementally by many people in the course of their normal responsibilities. A small metrication staff would have to be established. Standards development, and initiatives to capture specific metrication advantages for the Army, would require significant resources, but their expenditure would be constrained and governed by least cost criteria. DA-level commitment would be necessary to the successful implementation of this strategy. If least cost constraints are properly followed, none of these costs is beyond the Army's capability to provide; Strategy 6 is therefore feasible.

Adoption of this strategy would result in immediate support for metrication in new designs and in other areas of Army activity; progress would be limited only by the economic and operational constraints appropriate to each case. An information gathering and disseminating process would, in a short time, enable the Army to become aware of the pace of industrial metrication and plan its transition realistically. The Army would also be in a position to respond effectively to an accelerated national transition, should it occur; a costly emergency Army conversion program would be avoided. The focus of the Army conversion would be on advantages and benefits to be gained, such as the cost avoidance associated with a reasonably short transition. Armed with timely and relevant metrication information, the Army could identify industrial or governmental obstacles to Army conversion, and exert its influence to remove them, if the cost of such action appeared to be warranted in the circumstances. In short, the benefits which could be expected under this strategy approach the maximum attainable within the constraints imposed by DoDD 4120.18. The costs, as discussed above, would be under constraints and would probably be relatively small. It is therefore concluded that Strategy 6 is acceptable.

5.2.3 Comparison of Retained Strategy Options

Of the five Tentative Strategy Options initially framed (see Figure 5-2, Strategies 1-5), and the sixth Tentative Strategy Option developed during the course of the analysis, only the following (numbers 3 and 6) survived the testing process (as may be seen graphically in Figure 5-5):

3. Adopt metrics as practicable in all Army activities and prepare for an accelerated metric transition.

6. Capitalize on metric conversion by adopting metrics as practicable in all Army activities, preparing for an accelerated metric transition, and, when appropriate, promoting national metrication where advantageous to the Army.

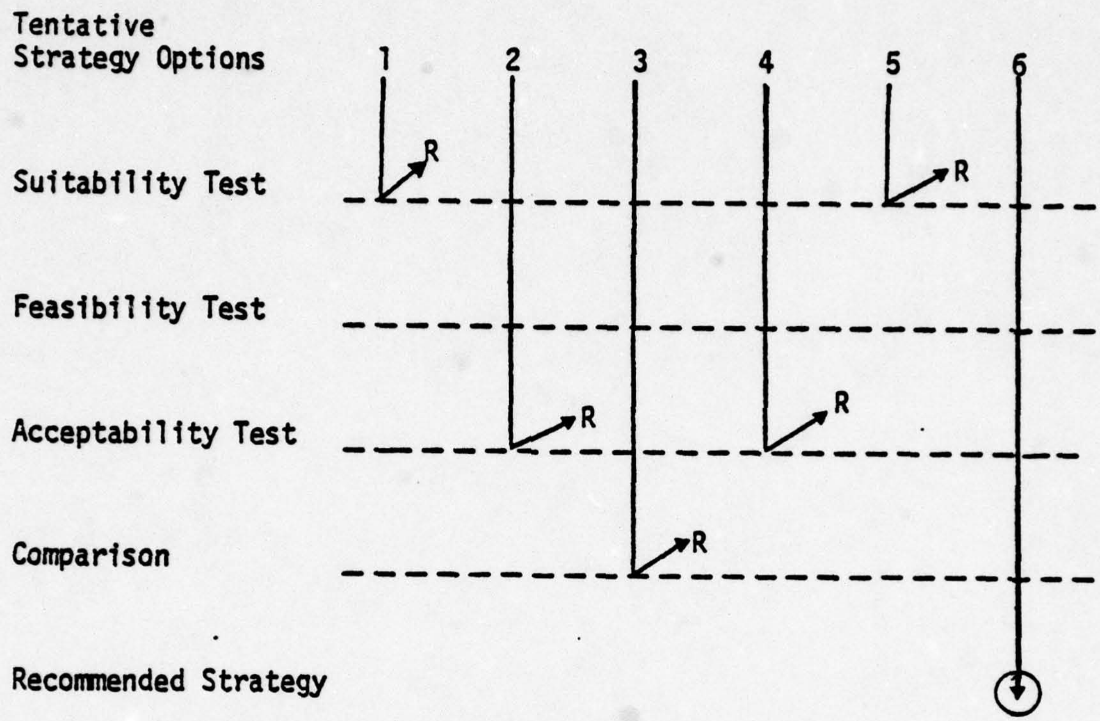
Strategy 6 is conceived as a combination of Strategies 3 and 4; the elements of Strategy 3 provide a necessary basis for the exercise of Strategy 4 later in the Army's transition. In other words, Strategy 3 is subsumed in Strategy 6, which embodies an advantage over Strategy 3: the option for the Army to actively influence metrication in industry or government to its own advantage. Hence, Strategy 6 has all the attributes of Strategy 3, plus the additional flexibility noted above. Strategy 6 is therefore judged superior.

5.3 Recommended Army Metrication Strategy

Capitalize on metric conversion by adopting metrics as practicable in all Army activities, preparing for an accelerated metric transition, and, when appropriate, promoting national metrication where advantageous to the Army.

FIGURE 5-5

SUMMARY OF STRATEGY TESTS AND COMPARISONS



<u>Note</u>:

R = Reject

CHAPTER 6

METRICATION TASKS FOR THE EXTANT ARMY ORGANIZATION

6.1 Introduction

The recommended strategy synthesized in Chapter 5 provides the conceptual basis for further development of a strategic Army metrication plan. Chapters 3 and 4, and especially Section 4.4.2 (Management and Organization), together with the recommended strategy, provide the necessary background for the discussion which follows. This chapter draws the important distinction between extant (existing, normal, conventional) Army organizations and the special (dedicated) metrication organization, and identifys the principal metrication tasks to be undertaken by the existing organization. Chapters 7 and 8 address the structure of, and the initial tasks for, the metrication organization, respectively.

6.2 Analytical Approach

That metrication must be planned and undertaken by affected individuals in the performance of their normal responsibilities is one of the basic principles of a successful metric transition. This point stressed repeatedly by foreign organizations and U.S. industry. Metric conversion becomes a fact through the efforts of existing organizations; a metric product is designed, developed, and manufactured by organizations which normally design, develop and manufacture products, not by a special metrication organization. The situation is analogous to the line-staff relationship. The function of normal or existing (line) organizations is to perform; the function of the metrication (staff) organization is to support.

Because metrication involves, or will involve, products and services of all varieties, a list of individuals who will necessarily be involved in metrication planning and implementation, in conjunction with their normal responsibilities, would be very long indeed. The

following list of decision-makers is representative, however:

Combat Developers
Integrated Logistic Support Managers
Logisticians
Materiel Developers
Materiel Managers
Procurement Contracting Officers
Program/Project/Product Managers
System Managers
System Support Managers
Trainers
Testers

It should be constantly kept in mind that normal responsibilities and functions remain intact during the metric conversion. Project Managers, for instance, continue to bear their responsibilities without diminution; similarly, ASARC responsibilities are not diminished when metric systems are reviewed. In both cases, however, metrication injects a new dimension into the acquisition process. This new metric dimension, moreover, raises new questions at all organizational levels, and in all phases of the system life cycle.

In view of the myriad Army activities subject to metrication, the large number of individuals who will be affected by metrication, and the principle that the "doers are the planners", it is clear that any task statements appearing in a strategic plan must be couched in general terms. Generality is necessary because the metric implications of a proposed project or undertaking will have to be considered at several organizational levels (e.g., PM, DARCOM, ASARC), and from several viewpoints (e.g., operations, logistics, cost). In other words, while the elements of any task may be broadly appropriate, specifics will vary by organizational level and viewpoint as well as the nature of the project or undertaking itself.

The conditions which require task statements to be general, coupled with circumstances unique to each project or undertaking, also prevent the framing of definitive solutions to metric problems or rules for action. An understanding of why this is so is essential

to a successful metric transition. It is here that the principle of metrication planning and implementation in conjunction with normal responsibilities becomes operative. If a project manager, for instance, is to remain responsible for his project, then he must deal with the metric implications and problems associated with his project. Only the PM knows his project intimately; the PM is normally the first to become aware of problems (including metric) associated with his project; the PM is in the best (or only) position to exercise ingenuity to find an acceptable, least-cost solution to a metric problem, or to recognize and capitalize on metrication opportunities which may develop. In other words, at the project level, only the PM is in a position to deal efficiently with the impact of metrication on his project.

Some further explanatory remarks will be helpful before proceeding to the task statements in Section 6.3. The purpose of this chapter is to identify various metrication tasks relevant to the normal line activities. There are any number of approaches which can be employed to attain this end. The analytical approach employed in this study is based on the rationale that the task statements should encompass those things which must be accomplished, by the line actions, to achieve the Army's metrication objectives. The objectives of an Army metrication plan are given in Figure 2-1 in categorized form. Extracted from DoDD 4120.18, the categorization, as discussed in Chapter 2, is somewhat arbitrary because the objectives are not mutually exclusive. The categorization is felt to be useful, however, in that it provides a framework which can show the relationship of the tasks to an exhaustive but manageable number of objectives.

Because the objectives are not mutually exclusive, it is quite likely that a proposed metric project will not solely support one metrication objective. Whether a project is believed to support one, or more, objectives makes little practical difference, however. Appropriate steps for the decision-maker, in investigating the implications of a metric project or undertaking, could be to determine which objectives are supported and then to address all tasks under those objectives, discarding any redundant tasks.

In Section 6.3, a set of tasks is given for each of the ten Army metrication objectives. In order to achieve any metrication objective, it was felt that task statements should address the following issues: policy development, guidelines for policy implementation, planning/coordination/communications tasks, documentation revision and resource allocation. Broadly speaking these issues are applicable to any one of the objectives. In order to ensure that omissions are avoided, a parallel approach of developing task statements relating to each of these issues for each objective has been adopted. The content and rationale for each of the task statements are as follows:

- Task 1 (Policy Development). The achievement of any objective normally starts with a policy statement. The policy developed should support the recommended strategy; its nature and scope will depend on the organizational level of the policy-maker. Pertinent guidance for policy development is given for Task 1 for each objective.

- Task 2 (Guidelines for Policy Implementation). With a policy established (Task 1), the next step is to issue some form of guidance in order to put the policy into effect. A battery of leading questions is given for the major areas pertinent to the objective of interest. Logistics questions are frequently raised. Further logistic information is given in Annex I. Similarly, Annex J, which deals with monitoring activities, should assist in answering some of the questions concerning industrial metrication progress.

- Task 3 (Planning/Coordination/Communication). Foreign and domestic metrication experience universally emphasizes the need for thorough and continuous planning. Coordination or communication among all affected entities is vital to both planning and policy implementation. An outline of generally accepted planning sub-tasks is given. Annex J also contains information related to coordination and communication which may be useful.

- <u>Task 4 (Documentation Revision)</u>. Because of the pervasive nature of any measurement system, countless measurement-sensitive references will have to be changed. More importantly, barriers to metrication will arise due simply to the measurement language; barriers will have to be identified, and action taken to remove or mitigate them. Annex K, a review of the metric impact on selected ARs, is representative of this task.

- <u>Task 5 (Resource Allocation)</u>. Metrication may entail some costs measured not only in dollars, but in man hours or personnel spaces. Properly managed, these costs can be accommodated, particularly at high organizational levels. At lower levels, however, cost considerations may become acute. Management at all levels should be sensitive to the need to reallocate resources (temporarily or permanently) in response to, or anticipation of, workload and cost changes incident to metrication.

A somewhat more focused treatment of metrication tasks from a project manager's point of view is given in Annex L, Program Manager's Checklist. Reference to Annex L in conjunction with Section 6.3 may provide a useful perspective.

6.3 Task Statements Supporting Army Metrication Objectives

Task statements in this Section are aligned with the Army metrication objectives, given in Figure 2-1, as follows:

6.3.1 Task statements which support DoD/DA metric transition in harmony with industrial conversion. (Four task statements, supporting objectives 1a-1d, are given.)

6.3.2 Task statements which support standardization with our Allies. (Two task statements, supporting objectives 2a and 2b, are given.)

6.3.3 Task statements which support metric usage in all activities consistent with operational, economic, technical, and safety requirements (four task statements, supporting objectives 3a-3d, are given).

6.3.1 Task Statements which Support DOD/DA Metric Transition in Harmony with Industrial Conversion

Objective 1a.

Enhanced defense-industry preparedness or defense production readiness.

Tasks

1. Establish policies to ensure enhancement of defense-industry preparedness in conjunction with metrication.

   Within the recommended strategy, Army policy should emphasize the recognition of benefits to be obtained by enhancing defense-industry preparedness through metric conversion. Army policy should allow for promotion of metrication of critical industries, by bearing incremental costs, where in the best interest of the Army.

2. Establish guidelines to implement policies for the enhancement of defense-industry preparedness.

   Guidelines should deal with issues such as:

   Identification of industries where defense preparedness or production readiness would be enhanced by metrication.

   Circumstances under which it may be advantageous for the Army to bear some incremental cost of industrial conversion. If an industry is not planning to metricate, will continued acceptance of its customary dimensioned products have a serious impact on Army logistics? Will it create interface problems?

   Methods for consideration of both current and life cycle costs and benefits in evaluation of supporting incremental costs of industry conversion. When will cost of supporting an inch product in the Army logistics system exceed the incremental cost of supporting industry conversion?

3. Assure that adequate planning is undertaken.

   Identify planning needs

   Identify prinicipals to do planning

   Assign responsibilities for planning

Provide appropriate and timely information to planners

Establish mechanisms for coordination where necessary

Intra-Army
Intra-DoD
Army-Industry

4. Prepare or revise regulations and directives to accommodate enhancement of defense-industry preparedness.

5. Allocate or reallocate resources to support Army enhancement of U. S. defense-industry preparedness and production readiness, as appropriate.

Objective 1b.

Acceptance of new materiel of metric design when production facilities are available.

Tasks

1. Establish policies which assure that the Army maintains awareness of industrial metric capabilities and that Army acquisitions and procurements take advantage of this capability.

   Under the recommended strategy, policies should stress the desirability of adopting metric materiel whenever practicable in order to maximize metrication benefits. To do this, the need for accurate, timely information regarding current and projected industrial metric capabilities should be emphasized, and this information should be obtained insofar as possible through normal Army-industry contacts. Policies should also assure that Army actions do not impede or hinder industrial conversion.

2. Establish guidelines for acceptance of new materiel of metric designs.

   Guidelines should address issues such as:

   a) Identity of industries, trade associations, and other organizations (such as ANMC sectors) to be monitored. What companies/industries are involved? What organization do these industries or companies belong to? What are the appropriate ANMC sectors? What standards writing bodies are involved?

   b) Identity and adequacy of existing channels which can be used to monitor industrial capability. What organizations, such as those listed above, do Army personnel currently participate in? Do you or can you get reliable, timely information from these individuals? Do you have contact with all of the groups identified in (a)?

   c) If required, the means by which existing monitoring channels can be augmented. By what means can you get timely information? through personnel? newsletters? etc?

Would subscription to an organization's newsletter, catalogues, journals, etc. provide sufficient information? Is personal contact essential to obtaining needed timely information?

d) Impact on logistics functions

(1) Training - Are there any training implications? Operator training? Maintenance? Are new or unique training demands generated? Are there existing or planned training programs to satisfy these requirements? Costs associated with training? Can training be accomplished on a timely basis?

(2) Supply - What are the supply implications? Are there interface problems? Will dual inventories be necessary? Does this create space, packaging, cataloging, etc., problems? Have the problems of long life equipment supply been considered?

(3) Maintenance - What are the maintenance implications for testing and servicing? calibration? need for and availability of metric tools?, etc.

(4) Testing and Evaluation - What are the T&E implications? What are the risks associated with a metric design? Are there interface problems with a metric design? with a hybrid design? Are production facilities available today? Will they be available when the project reaches the production phase? Effect on military utility?

(5) Quality Assurance - Requirements documents available today or planned for? Impact on TMDE? Is metric or dual readout equipment available? Impact on data base, continuity of records?

e) Impact on documentation and decision-making associated with the systems acquisition process. Has metrics properly been considered in DCPs (Division Coordinating Papers)? Documents relating to IPRs and ASARC? Is consideration given to the trend towards national metrication which renders new inch-pound system obsolescent?

3. Assure that appropriate planning is undertaken.

   a) Identify principals

   b) Assign planning responsibilities, if necessary

   c) Provide information required for planning

   d) Establish communications network among prinicipals

   e) Establish communications networks with entities external to Army where necessary to facilitate planning

4. Prepare/revise ARs, ASPRs/DARs, and other directives as necessary to accommodate/facilitate metric procurement.

5. Assure that adequate resources are provided to support necessary monitoring activity.

Objective 1c.

Acceptance of industry conversion with minimum cost.

Tasks

1. Establish policies which support a least cost conversion.

   Under the recommended strategy, the key policy elements of a least cost strategy should include: emphasis on maximization of benefits in any area as the opportunity arises; consideration of both current and life cycle costs in evaluating metrication; a systematic, planned, evolutionary conversion on all fronts at once; keeping pace with industry; phasing activities with normal review processes where possible.

2. Establish guidelines for implementation of least-cost policies. Guidelines would be necessary for items such as:

   1) Recognition and assessment of short and long term benefits. Have benefits due to simplified calculations, especially logistic calculations, been considered? Benefits due to simplified and improved communication? rationalization of products and/or practice?

   2) Consideration of initial and life cycle costs. What are the life cycle costs for an inch product? What are the life cycle costs of a similar metric product? Under what circumstances will a higher initial cost for a metric item be paid?

   3) Consideration of hybrid designs. If a hard metric product is not feasible, does a hybrid design offer advantages? Does adoption of a hybrid design create problems regarding interface, interoperability, interchangeability, etc.? Have long term costs and benefits of the hybrid design been considered?

   4) Consideration of logistics impacts.

      a) Training needs - can metrics be integrated with normal training?

      b) Supply - are there costs associated with supply of metric items?

c) Maintenance - are there costs associated with maintenance aspects?

d) T&E - what is the impact on T&E?

e) QA - are there effects on QA?

5) Monitoring industry to assess status and plans.

3. Ensure that effective, detailed planning occurs.

   Identify principals who should do planning

   Assign responsibilities, where necessary

   Provide required information

   Coordinate Intra-Army planning

   Coordinate Army planning with relevant external plans (i.e., DoD, other DoD Components, Federal Government, Industry).

   Establish communications networks (formal and informal) by which metric information can be exchanged to facilitate planning.

   Ensure timely dissemination of information essential to assuring least cost transition.

4. Review and revise regulations, procedures, standards and other documentation as necessary to accommodate or facilitate metrication.

   Assure that metric requirements can be stated clearly in contracts while allowing contractor flexibility in meeting them.

   Consider use of metrics in DCPs (Defense Coordinating Paper) and other acquisition documents.

   Revise procurement regulations and procedures, e.g., to allow purchase of common metric tools on an Army-wide basis instead of charging them to each project.

5. Review the impact of metrication activities on available resources.

   Provide for any reallocation of or incremental increase in resources, as necessary.

Objective 1d.

Acceptance of industry conversion with minimum disruption of operations.

Tasks

1. Establish policies to assure a harmonious transition with minimum disruption of operations.

   Because of its military role, minimum disruption of operations is a key element of the Army metric conversion. This concept is not unlike that of U.S. industry in approaching metrication. Under the recommended strategy, the Army would have maximum flexibility in meeting this objective. Policy statements should focus on reinforcement of the minimum disruption concept and the active seeking of opportunities for enhancing operational readiness. Strong emphasis should also be given to the need for realistic and coordinated planning.

2. Establish guidelines to ensure a harmonious transition with minimum disruption.

   Guidelines should address issues such as:

   a. Impact of metrication on logistics:

      Training: What metric training is required to minimize disruption of operations? Impact on recruit training? On Military Occupational Specialties (MOS)? Implications for operational readiness? Timing?

      Supply: Is the supply system ready to accept metric items? Consideration of cataloging, receipting, storage, issue, etc. with respect to dual inventories? Recognize and capitalize on opportunities to rationalize, simplify supply opeations?

      Maintenance: Is the maintenance system ready to accept metric items? What are impacts of metrication at each maintenance level? What implications for

operational readiness? Availability of metric tools, documentation?

<u>T&E:</u> What are the T&E implications? Does the adoption of a metric item pose unique T&E problems in relation to interoperability, interchangeability, maintainability, etc.?

<u>Quality Assurance</u>: Requirements documents available today or planned for? Impact on TMDE? Is metric or dual readout equipment available? Impact on data base, continuity of records?

b. Assure effective management of metric trained personnel assignments. Who are the metric trained personnel? What are their skills/qualifications/MOS? Does the current personnel accounting system permit ready identification of these individuals? Where will metric trained personnel need to be assigned?

c. Assure that BOIPs (Bases of Issue Plans), TOEs (Tables of Organization, and Equipment) and other planning documents associated with the LCSMM (Life Cycle System Management Model) address special requirements imposed by metrication. Is consideration given to the concept of solely metric and solely inch equipped military units? What about hybrids?

d. Consideration of accepting incremental costs of metrication where advantageous to the Army. Are there barriers to metrication which are or potentially will disrupt operations? If so, would the benefits accruing to the Army by removing the barrier be worth the costs?

3. Assure that appropriate planning is undertaken.

Identify the principals involved in planning.

Provide necessary information for planning.

Establish mechanisms for coordination of intra-Army planning.

Establish mechanisms to coordinate Army plans with DoD Components.

4. Prepare or revise ARs and other documentation and procedures to facilitate metrication with minimum disruption of operations.

5. Allocation or reallocate resources as necessary to minimize disruption of operations.

6.3.2 Task Statements Which Support Standardization With Our Allies

Objective 2a.

Adoption of new materiel of metric design for Allied use, foreign military sales and/or joint production.

Tasks

1. Establish policies to ensure that metric designs of new materiel are considered for adoption where the materiel is for Allied use, has foreign military sales potential and/or is slated for joint production.

   The RSI (Rationalization, Standardization and Interoperability) Program, focusing on enhancements of the military capabilities of the NATO Alliance with Allies, has direct and substantial metric implications. The Army's RSI and metrication objectives are complementary. Policy statements under the recommended strategy should emphasize the benefits and opportunities afforded; they should also provide for coordination of metrication activities undertaken in the context of the RSI program with those undertaken with respect to DoD 4120.18.

2. Establish guidelines to ensure consideration of metric designs of new materiel for Allied use.

   Guidelines would address issues such as:

   a) Identification of candidate materiel. Is the candidate materiel being considered under the RSI program? What systems are being considered for foreign military sales? for joint production? for Allied use?

   b) Industry capability/plans for producing in metric. Can it be produced? At no cost premium? Can it be produced at little or no cost premium when needed? With respect to joint production, what are the U.S.-foreign industry interface problems?

   c) Standards availability. Are appropriate standards available? Can they be developed and/or certified within project time frame? At what cost?

d) Materials availability. Available now at no cost premium? Available when needed at no cost premium? Is foreign procurement feasible? Are the sizes of materials required by the Army compatible as preferred sizes adopted by U.S. and foreign industries?

e) Benefit recognition and assessment. Are military operational capabilities enhanced? Interoperability with Allies? Simplified communications? Balance-of-payments enhanced? Support of RSI program?

f) Consideration of initial and life cycle costs. What are the life cycle costs for an inch product? What are the life cycle costs of a similar metric product? Under what circumstances will a higher initial cost for a metric item be warranted?

g) Impact on logistics functions:

   (1) Training - Are there any implications? Operator training? Maintenance? Are new or unique training demands generated? Are there existing or planned training programs to satisfy these requirements? Costs associated with training? Can training be accomplished on a timely basis? What about training of Allied/foreign personnel?

   (2) Supply - What are the supply implications? Are there interface problems? Will dual inventories be necessary? Does this create space, packaging, cataloging, etc., problems? Have the problems of long life equipment supply been considered, especially for foreign military sales?

(3) Maintenance - What are the maintenance implications for testing and servicing? Calibration? Need for and availability of metric tools, etc? Are there additional documentation problems associated with foreign/Allied use?

(4) Testing and Evaluation - What are the T&E implications? What are the risks associated with a metric design, especially with respect to foreign use? Are there interface problems with a metric design? With a hybrid design? Effect on military utility?

(5) Quality Assurance - Requirements documents available today or planned for? Impact on TMDE? Is metric or dual readout equipment available? Impact on data base, continuity of records?

h) Incremental costs. Under what circumstances would it be advantageous for the Army to absorb some incremental costs in order to adopt a metric design for Allied use, joint production, or foreign military sales?

3. Assure that appropriate planning is undertaken.

Establish mechanism for planning, coordination and communication.

Identify principals.

Assign planning responsibilities, where necessary.

Establish mechanisms for intra-Army, intra-DoD coordination.

Establish mechanisms to coordinate Army metrication efforts with RSI programs, foreign military sales programs and joint production programs, where appropriate.

Identify information needs and sources.

Establish mechanisms for collection and dissemination of metric information.

4. Prepare/revise ARs and other directives to facilitate adoption of metric designs for Allied use, foreign military sales, or joint production.

   Revise procurement regulations and policies as needed.

5. Allocate or reallocate resources to support adoption of metric designs from new materiel for Allied use, foreign military sales or joint production.

Objective 2b.

Participation, to the extent of Army/DoD interest, in the development of national and international metric standards; adoption of international metric standards which meet or exceed definitions and restrictions established by U.S. standards.

Tasks

1. Establish policies to ensure active participation in appropriate standards-writing groups and promote adoption of international metric standards where possible.

   Under the recommended strategy, standards development is a major undertaking for the Army, involving writing, rationalization and certification of new metric standards. Policy statements should strongly emphasize the benefits to be gained by adopting international standards wherever possible by the seeking of opportunities to rationalize product varieties and sizes and minimizing development of new metric MILSTDs and MILSPECs. Soft conversion should be allowed as an initial approach but the development of hard metric standards should be promoted, with acceptance of associated incremental costs where in the Army's best interest.

2. Establish guidelines for standards development and adoption.

   Define Army product-oriented interest in metric standards-development. What standards or families of standards are required for systems/products proposed for, or in the early phases of, development. Are suitable metric standards available? ISO? U.S. industrial? MILSTDs? Would it be in the best interest of the Army to absorb some incremental costs in order to provide for the development of selected metric standards or groups of standards?

   Define Army interest in general metric standards development stemming from recognition of the inevitability of Army metric conversion. What MILSTDs are measurement sensitive? What criteria are useful for establishing priorities for converting/developing new metric standards or groups of related standards? Are both product driven and general metrication needs considered? Which standards needs can be met by soft conversion of existing standards? Can soft conversion be incorporated into the normal standards review process? Where new hard metric standards are required,

has consideration been given to opportunities for rationalization? Are national and international efforts towards rationalization applicable to Army needs?

Consider certification demands generated by adoption of new standards. Which new standards require certification or recertification? Can the Army's certification or recertification needs be minimized through active participation in the development of these standards? Would standards certification externally (e.g. NATO, ISO or National certification) be acceptable? Can the certification workload be reduced through cooperative or joint efforts with the other Services or standards-writing groups? Can standards be recertified on a timely basis, where there is a specific need? How can standards certification be programmed to minimize associated costs?

3. Assure appropriate planning is undertaken.

Identify standards-writing groups in which the Army should participate.

Ensure participation in identified standards-writing groups:

Identify current participation.

Identify gaps.

Assign responsibilities for participation in areas where the Army is not active but should be.

Ensure that funding and time allocations are made.

Ensure coordination of standards-writing and certification activities where necessary.

Determine need for coordination

Establish mechanisms for coordination of Intra-Army standards writing and certification activities where necessary.

Establish mechanisms to assure effective coordination of standards-writing and certification activities with other Federal agencies and DoD components.

Ensure effective communication of standards-writing information and certification on a timely basis.

Establish mechanisms for collection and dissemination (e.g., newsletter, memo, meeting, etc.)

4. Prepare/revise regulations, procedures and other documentation to accommodate development of metric standards.

5. Allocate or reallocate resources to support the development of appropriate metric standards.

6.3.3 Task Statements Which Support Metric Usage in All Activities Consistent with Operational, Economic, Technical, and Safety Requirements

Objective 3a.

Metric usage for designs of new materiel.

Tasks

1. Establish policies which ensure consideration of metrics in all new designs.

   Under the recommended strategy, a particular policy emphasis should be given to metric usage in designs for new materiel. In support of a forward-looking policy, particular emphasis should be given to the seeking of advantages and opportunities associated with metrication of new designs. An integral element of the policy is a consistent and realistic consideration of metrics at key decision points in the system acquisition process. Where 100% metric designs are infeasible, hybrid designs should be acceptable as an interim approach.

2. Establish guidelines for consideration of metrics in new designs.

   Guidelines would address issues such as:

   a) Standards availability. Are appropriate standards available? Can they be developed and/or certified within project time frame? At what cost?

   b) Materials availability. Available now at no cost premium? Available when needed at no cost premium? Is foreign procurement feasible? Are the sizes of materials required by the Army compatible with preferred sizes adopted by U.S. and foreign industries?

   c) Industry capability/projections. Can it be produced? At no cost premium? Can it be produced at little or no cost premium when needed? If a 100% metric product is not feasible, to what extent could a hybrid product be produced?

   d) Consideration of initial and life cycle costs. What are the life cycle costs for an inch product? What are the life cycle costs of a similar metric

product? Under what circumstances will a higher initial cost for a metric item be warranted? Are there implications for safety? What are costs associated with a hybrid design? Are the metric sizes desired by the Army compatible with preferred sizes adopted by industry.

e) Benefit recognition and assessment. Are military operational capabilities enhanced? Interoperability? Simplified communications?

f) Impact on logistics functions:

(1) Training - Are there any training implications? Operator training? Maintenance? Are new or unique training demands generated? Are there existing or planned training programs to satisfy these requirements? Costs associated with training? Can training be accomplished on a timely basis?

(2) Supply - What are the supply implications? Are there interface problems? Will dual inventories be necessary? Does this create space, packaging, cataloging, etc., problems? Have the problems of long-life equipment supply been considered?

(3) Maintenance - What are the maintenance implications for testing and servicing? calibration? need for and availability of metric tools, etc.?

(4) Testing and Evaluation - What are the T&E implications? What are the risks associated with a metric design? Are there interface problems with a metric design? with a hybrid design? Are production facilities available today?

Will they be available when the project reaches the production phase? Effect on military utility?

(5) Quality Assurance. Requirements documents available today or planned for? Impact on TMDE? Is metric or dual readout equipment available? Impact on data base, continuity of records?

g) Interoperability/Interchangeability Issues. Has consideration been given to interoperability/interchangeability requirements? Has due consideration been given to long term effects, recognizing the national trend towards metrication? Do hybrid designs create any unique problems?

3. Assure that adequate planning is undertaken.

Identify planning needs.

Identify principals to do planning.

Assign responsibilities to do planning.

Provide appropriate and timely information to planners.

Establish mechanisms for coordination where necessary.

Intra-Army

Intra-DoD

Army/Industry

4. Prepare or revise regulations, directives and other documentation (including ASPRs/DARs) to facilitate adoption of metric designs for new materiel.

Incorporate metric criteria in the system acquisition decision process (IPR, DSARC/ASARC) and revise planning documents of the LCSMM (Life Cycle Systems Management Model).

5. Allocate or reallocate resources to support Army adoption of metric designs for new materiel.

Objective 3b.

Metric usage in the procurement of all supplies and services.

Tasks

1. Establish policies which assure proper and general consideration of metrics in the procurement process.

   Under the recommended strategy, advantages offered by metrication with respect to procurement of all supplies and services should be seized whenever opportunities occur. So that opportunities may be recognized, policies should support monitoring of industrial metrication progress and activities and participation in appropriate metrication planning forums. This effort should be undertaken, by individuals, to the maximum extent possible, in conjunction with the performance of their normal responsibilities.

2. Establish guidelines for the procurement of metric supplies and services.

   Guidelines should address issues such as:

   a) Industry capabilities/plans: Can industry provide the metric items/service? At any premium? Will a metric item/service be available within the time frame of concern? For the industries of interest, what are the planned conversion dates? Which affect Army? Is the metric item/service of interest to the Army compatible with preferred sizes adopted by the industry?

   b) Standards availability: Are standards pertinent to the item/service? Are appropriate metric standards available? If not available, will they be available at some future date? When?

   c) Materials availability: Is the procurement of metric materials of concern? Are they available? When will they be available?

   d) Costs: Are there any cost premiums for metric items? Is there any justification for paying cost premiums?

e) Benefits: What are the benefits to be obtained for procuring metric supplies and services? Are there any disbenefits associated with metric procurement of supplies and services?

f) Impact on logistics functions:

(1) Training - Are there any training implications? Operator training? Maintenance? Are new or unique training demands generated? Are there existing or planned training programs to satisfy these requirements? Costs associated with training? Can training be accomplished on a timely basis?

(2) Supply - What are the supply implications? Are there interface problems? Will dual inventories be necessary? Does this create space, packaging, cataloging, etc., problems? Have the problems of long life equipment supply been considered?

(3) Maintenance - What are the maintenance implications for testing and servicing? Calibration? Need for and availability of metric tools?, etc.

(4) Quality Assurance - Requirements documents available today or planned for? Impact on TMDE? Is metric or dual readout equipment available? Impact on data base, continuity of records?

3. Assure that appropriate planning is undertaken.

a) Identify principals.

b) Assign planning responsibilities, if necessary.

c) Provide information required for planning.

d) Establish communications network among principals.

e) Establish communications networks with entities external to Army where necessary to facilitate planning.

4. Prepare/revise ARs, ASPRs/DARs, and other directives as necessary to accommodate/facilitate metric procurement.

5. Allocate or reallocate funds to support procurement of metric supplies and services.

Objective 3c.

Orderly programming and budgeting actions which support the transition to SI.

Tasks

1. Establish policies to assure orderly programming and budgeting actions which support the transition to SI.

   Under the recommended strategy, a minimum cost strategy is pursued. Basic policy statements should endorse the concept of letting costs lie where they fall--with emphasis on reallocation of existing resources to respond to changing conditions and priorities. Criteria for reallocation of resources to support metrication should be to capitalize on metrication through capturing of specific advantages or removal of barriers.

2. Establish guidelines for programming and budgeting actions which support the transition to SI.

   Guidelines should address the following issues:

   Criteria for Reallocation of Resources to Capture Benefits. Will military operations be enhanced? To what extent? Enhancement of standardization with Allies? To what extent? Defense-industry preparedness? To what extent?

   Criteria for Reallocation of Resources to Remove Barriers. Are there barriers? Are the effects of the barrier isolated and specific or are they pervasive throughout the Army? Could they be mitigated by reallocation of funds to meet changes in priorities and responsibilities attributed to metrication? What changes in budgeting, programming and resource allocation procedures are required?

   Monitoring Metrication Costs. What, if any, metrication costs should be identified and tracked? Are there any Federal/legislative requirements to track specific metrication costs? Can these costs be tracked by normal accounting procedures and systems or are changes necessary? Are there provisions for incorporation of necessary metrication costs in budget documents? Can metrication budgeting tasks be incorporated in the normal budgeting procedures?

3. Assure that appropriate planning is undertaken.

   Identify principals.

   Assign planning responsibilities, where necessary.

   Establish mechanisms for intra-Army, intra-DoD coordination.

   Establish mechanisms for collection and dissemination of required information.

4. Prepare/revise ARs and other directives as needed to accommodate budgeting needs for metrication.

Objective 3d.

Adherence to accepted SI units.

Tasks

1. Establish policies to assure adherence to accepted SI units in all documentation and practice.

   The principal advantage offered by metrication is improved communications by means of a universal measurement language. Improvements in communications will be diminished to the extent that deviations from accepted SI units, as defined in ISO 1000, are authorized. Pursuant to the recommended strategy, which emphasizes the maximization of benefits, policy statements should prescribe closely adherence to SI. Policy should require the use of SI in all documentation; use of dual units should be deprecated.

2. Establish guidelines for adherence to accepted SI units.

   Ensure that SI is used in appropriate documentation (technical reports, studies, position papers, active records, etc.). Is the subject of the document measurement sensitive? Does the document deal with metric or hybrid items? Is dual dimensioning essential to the understanding of the document?

   Evaluation of the Need to Convert Existing Documentation. Is it measurement sensitive? Is there a clear need to convert the document to SI? Can this be done on a routine or programmed basis?

   Evaluate the Impact on Automated Data Processing. Will the record/program have accommodate both SI and customary units? Are there software problems? Are programs/algorithms available? SI usage guides available? Programmers trained? Can more or larger data fields be accommodated? Are there hardware problems? Is additional storage necessary? Available?

3. Ensure that appropriate planning is undertaken.

   Identify planning requirements:

   1) Identifying principals

2) Identify key tasks and assign responsibilities.

3) Provide appropriate information.

4) Coordinate activities where necessary.

4. Prepare or revise ARs and other directives to facilitate use of, and adherence to, SI units in documentation.

5. Allocate or reallocate resources where necessary to facilitate use of and adherence to SI in documentation.

6.4 Relationship of Extant Organizations to the Metrication Organization

The decision-maker, in his investigation of the impact of metrics on his project or undertaking, will probably find that some necessary metrication information is not at hand. Project managers, for instance, facing metrication problems and questions for which they have no immediate answers, have several avenues of information available to them, principally their normal vertical reporting chain and horizontal contacts with staff elements of appropriate Major Subordinate Commands. If contractors (companies) are involved, they, too, can provide pertinent metrication information. While existing avenues of metric information will not be altered by the metric transition, they will not be adequate for growing national or Army metrication involvement. Supplementary avenues for the flow of metrication information will be required. This network of supplementary avenues will provide the interface between extant organizations and the metrication organization.

The role of the metrication organization should be to support decision-makers in existing organizations first, by responding to queries from any decision-maker, and second, by disseminating metric information of general interest and by serving as a repository of metric information to be tapped as needed. In other words, the flow on this supplementary network would be in both directions -- to decision-makers who need specific information, and from those who report metric developments affecting the Army. For instance, industrial metric developments in any sector may be valuable to several Army organizations; aerospace metrication progress coming to the attention of MIRADCOM will certainly be of interest to AVRADCOM and all PMs dealing with aerospace projects. In the same way, solutions to metric problems, developed by any Army organization, should also be disseminated so that others may benefit from the experience.

Supplementary avenues for metrication, in addition to conveying information, must serve decision-makers in another sense. Where

administrative or funding barriers to metrication are discovered which affect more than a few existing Army organizations, or which are otherwise of a general nature, a means to put the problem before the appropriate decision-maker or group will be essential. Certain ASPRs inhibiting metrication could fall into this category, for instance. It will be the function of the metrication organization to initiate appropriate corrective action in response to problems of this nature, which cross normal organizational boundaries.

The avenues and types of metrication information, briefly discussed above, describe an interface between existing organizations and the metrication organization. Points of contact within existing organizations will have to be established. These points of contact could take any of several forms, depending on the size of the organization, the nature and variety of its activities, and the desires of the decision-makers. For instance, the decision-maker himself could be the contact, or a metric coordinator could be designated, or several individuals could be designated for particular areas of interest. The metrication point of contact function, however assigned, should complement the individual's normal responsibilities, i.e., a space dedicated to metric coordination would not be appropriate.

In summary, decision-makers in existing Army organizations will require support as Army metrication progresses. Support will take the form of two-way information exchanges and a means to identify and resolve metrication problems of general applicability. It will be a function of the metrication organization to disseminate metric information and to initiate action to resolve metrication problems. Metrication points of contact in virtually all existing organizations will be required in order to establish the metrication communication network.

CHAPTER 7

U. S. ARMY METRICATION ORGANIZATION

Metrication is a pervasive and complex task, which is often difficult to define clearly. It is also a temporary task and the organization set up to handle metrication should reflect the temporary nature of the task. The experiences of both foreign countries and U. S. companies provide substantial insight into methods for organizing and managing metrication. Throughout this discussion we will draw heavily upon the knowledge and insights gained from these sources.

7.1 HQDA Actors and Responsibilities

The first question which arises with respect to organization and management of metrication is: Who should be assigned the ultimate responsibility for metrication within the organization? Foreign practice has been to assign ultimate national responsibility to a governmental entity which has a major interest in metrication because of the nature of its normal work. In South Africa, the Minister of Economic Affairs had ultimate responsibility; the Metric Advisory Board reported to him. The Australian Metric Conversion Board reports directly to the Minister for Science and Education, who is directly responsible for Australian metric conversion. The assignment of responsibility is, of course, dependent upon the structure of the government. Note in both of these cases, however, that the Minister who has ultimate responsibility heads a governmental entity which will experience a major impact from metric conversion.

The practice of U. S. companies is particularly instructive in developing a recommendation to the Army. In a U. S. company, the individual with ultimate responsibility for the management of metric conversion is generally the Vice President of the area which will be

most strongly affected by metric conversion. Depending on the normal organizational structure of the company, this may be Engineering Standards, Manufacturing or some other area. The common thread which runs through foreign and domestic experience is that the ultimate management responsibility for metrication within an organization should lie with the high level individual whose area of normal responsibility will be most strongly and immediately affected by metrication.

In determining the ultimate responsibility for metrication in the U. S. Army, consideration should be given to the approaches which foreign countries and U. S. companies have employed, particularly those of U. S. companies. The responsible individual in the Army should be high level (equivalent to a Corporate Vice President), with access to the highest level management. An examination of the Department of the Army Organization Chart and AR 10-5 indicates that an appropriate candidate for this responsibility is the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA). He would be analagous to the Vice President for Manufacturing in a major U. S. corporation. DCSRDA appears to be the best candidate for several reasons. As defined in AR 10-5, DCSRDA has major responsibility for the research, development and acquisition of U. S. Army materiel as well as product improvements, non-materiel development and management of U. S. Army materiel. Assigning responsibility for metrication to him would be highly compatible with his current responsibilities. Secondly, metrication will have a major impact on the Army in the research, development and acquisition (RD&A) areas. Decisions regarding metrication in RD&A areas will, in turn, impact other areas of responsibility--but RD&A is the focus of major impacts of metrication. To assign responsibility to some other element of the Army Staff would be less appropriate and compatible, hence less effective. Therefore, it is recommended that primary responsibility for Army metrication be assigned to DCSRDA.

7.2 DARCOM as "Lead Department"

Foreign and domestic experiences provide additional insight into organization for metrication with respect to delegation of authority. In foreign experience, while the Minister of a government department has ultimate responsibility for metrication, he frequently delegates authority to a subordinate to deal with the matter. Similarly, this practice is followed in U. S. companies. Depending upon the corporate structure, responsibility for and authority with respect to metrication activities are assigned to a subordinate, usually the Department Head of the "lead" department (or group or division). The lead department is generally that entity which will experience major and immediate impacts of metrication. Depending on the corporate structure, it may be a major manufacturing division, the Standards Department, or the Engineering Department. Generally the entity designated the lead department is characterized by the fact that decisions it takes with respect to metrication will have pervasive impacts.

By analogy, it is likely that HQDA (DCSRDA) will assign the majority of the work to a subordinate, probably the Commanding General (CG) of a Major Army Command. The most logical candidate is the Commanding General of the United States Army Materiel Development and Readiness Command, whose principal functions include: research; development; product, production, and maintenance engineering; testing and evaluation of materiel; production and procurement of materiel; inventory management; and storage, distribution, maintenance, transportation, and disposal of materiel. These functions will be strongly affected by metrication decisions and the incorporation of metrication responsibilities into normal CG DARCOM functions results in homogeneity of assignment. Assignment of responsibilities to a Major Command other than DARCOM would be less effective and would result in less homogeneous assignment. In addition, decisions taken by DARCOM with respect to metrication will affect the activities of the other Major Commands. It would be advisable to assign DARCOM the "lead department" status to facilitate coordination and smooth conversion.

7.3 Unique Metrication Organizational Entities

In addition to assignment of metrication responsibilities to normal, existing organizational entities, foreign and domestic experience and practice suggest that two temporary organizational elements, dedicated to metrication, are essential to an orderly cost-effective metric conversion. These two entities, solely concerned with metrication, are a metric policy group, and a metric coordinator with a small staff. Each of these organizational entities is discussed below.

7.3.1 Metric Policy Group

In U. S. industry, the Metric Policy Group of a corporation is a high level advisory group. It serves to facilitate corporate metrication through formulation of policy and issuance of guidance to management at all levels. The Army Metric Policy Group is envisioned as a high level advisory group which fills roles similar to those filled by equivalent corporate policy groups. The Army Metric Policy Group would comprise high level participants who could activate their own organizations. The major functions which the Army Metric Policy Group would serve include:

1) Define Army metrication goals and directions;
2) Develop and recommend metrication policies;
3) Approve Army metrication plans;
4) Review proposed revisions to metrication plans;
5) Provide top level support and commitment to Army metrication efforts;
6) Review Army metrication progress on a periodic basis;
7) Provide advice and guidance on metrication issues to both higher and lower level management.

As is the case with corporate metric policy groups, the Army Metric Policy Group must be composed of individuals of high rank, preferably the Commanding Generals of the Major Army Commands and senior individuals from other elements of the Army Staff. Membership in the Metric Policy Group should be large enough to include those

most affected but small enough to ensure that the body is functional. It is recommended that membership be provided by the following Army Staff elements and Major Army Commands:

1) Deputy Chief of Staff for Logistics
2) Deputy Chief of Staff for Operations and Plans
3) The Comptroller of the Army
4) The Surgeon General
5) Chief of Engineers
6) U.S. Army Materiel Development and Readiness Command
7) U.S. Army Training and Doctrine Command

In addition to the membership listed above, consideration should be given to including the Deputy Chief of Staff for Personnel and the Adjutant General. Both entities appear to have significant interest in metrication. The Deputy Chief of Staff for Personnel (DCSPER) would have interest in metrication due to his staff responsibility for personnel distribution to include grade and occupational specialties, personnel utilization, individual training and others, as defined in AR 10-5. The Adjutant General (TAG) is the principal adviser to the Chief of Staff for Army administrative systems, administrative systems development, personal environmental programs, and U.S. Army Reserve personnel and administrative systems. TAG has numerous defined responsibilities with respect to these areas. Metrication can have significant impacts on some of the administrative systems and it may be useful to involve the Adjutant General in metrication policy development, at least with respect to his areas of responsibility.

It may not be necessary to include these two elements as permanent members of the Metric Policy Group. In the AR which establishes the group, provision should be made to call upon any element of the Army to contribute where necessary.

In the earlier discussion, it was recommended that major responsibility for Army metrication be assigned to DCSRDA. The question arises as

to whether DCSRDA should participate as a member of the Metric Policy Group. Three reasonable possibilities exist:

1) DCSRDA has membership on the Policy Group and acts as Chairperson.

2) DCSRDA has a membership on the Group, with CG DARCOM as Chairperson of the Group.

3) DCSRDA does not participate as a member of the Group.

Option 1 listed above would be applicable if DCSRDA is given major responsibility for Army metrication and elects not to assign the bulk of this work to CG DARCOM. In this situation, DCSRDA should have membership on the Group and should chair it.

The second option might be applicable where CG DARCOM is assigned major responsibility and DCSRDA wishes to sit on the Metric Policy Group. Both the first and second options, however, have a serious disadvantage. One of the Metric Policy Group's major roles is to provide policy recommendations to higher level management. Under either of the two options, participation by DCSRDA, the decision-maker, could inhibit the functioning of the Group. The second option also leads to a situation where CG DARCOM exercises authority over the superior to whom he reports.

The third option is for DCSRDA to remain independent from the Metric Policy Group. Since DCSRDA is the decision-maker with respect to metrication and the Metric Policy Group is seen as an advisory body, this appears to be the best option. DCSRDA would delegate sufficient authority to allow CG DARCOM to chair the Group and to assure that high level participation is achieved. In this arrangement, the Chairperson of the Metric Policy Group would report directly to DCSRDA. DCSRDA would review recommendations by the Policy Group and would be the ultimate arbiter in cases where the Policy Group could not resolve a specific problem.

It is essential that membership on the Metric Policy Group be top level individuals who are capable of activating their own organizations. The authority and influence of the Metric Policy Group

would be derived from the _ex officio_ authority of the individuals who sit on the Group, plus that derived from the terms of reference in the AR and/or charter which establishes the Group. The Metric Policy Group would most likely meet only infrequently (perhaps quarterly) thus facilitating senior membership, which is essential to assuring the success of Army metrication efforts.

7.3.2 The Metric Coordination

In addition to the Metric Policy Group, it is recommended that the U.S. Army appoint a Metric Coordinator and provide him with a small staff. Both U.S. industrial and foreign national practice demonstrate the value of a full time Metric Coordinator with a _small_ staff. General Motors' experience is instructive. GM's metrication efforts are handled by two professionals and a secretary. While GM and the Army are not exactly the same, the scope and magnitude of metrication are similar and lead to the suggestion that the Army may require only a small number of dedicated individuals to deal with metrication issues and problems.

The Metric Coordinator and his staff would have major responsibility for the day-to-day aspects of managing metrication in the Army. In carrying out his responsibilities, the Metric Coordinator would report directly to the Chairperson of the Metric Policy Group. The Coordinator and his staff would also provide information and recommendations to the Metric Policy Group, serving as secretariat to the Group. Aspects of particular interest to the Metric Policy Group, where the Metric Coordinator would provide input, include:

1) Recommendations on plans and plan modifications or adjustments;
2) Recommendations on policy;
3) Recommendations on guidelines for implementing metric conversion;
4) Information to facilitate monitoring and review of progress.

The Metric Coordinator would sit as a member of the Metric Policy Group. Figure 7-1 lists the recommended membership of the Metric Policy Group.

The major purpose of the Metric Coordinator, and his staff, is to facilitate Army metrication wherever possible. While the Metric Coordinator would not perform line management functions he would carry out two major activities which are essential for overall good management of change: establishment of a communication/coordination network within the Army, and collection and dissemination of metric information.

One of the major activities of the Metric Coordinator would be to establish and maintain a network of contacts with all elements and individuals involved with Army metrication. The network would include Army Staff elements, major Army Commands, the Major Subordinate Commands and System/Program/Project Managers.

In conjunction with this activity, the Metric Coordinator (i.e., his office) must serve as an information center. His responsibilities would include disseminating information, fostering the lateral transfer of information, assisting in the development of detailed plans, and maintaining an awareness of progress and current status of Army metrication. He would also perform a coordinating function and in this capacity would engage in conflict resolution. An additional responsibility would be to ensure contact with the external environment, including government agencies. DoD Components and U. S. industry. In this role, the Metric Coordinator would provide guidance and information to those involved with metric conversion, either directly or by bringing together knowledgeable individuals to deal with specific tasks and problems.

Because of the pervasive nature of the changes precipitated by metrication, the personality characteristics of the Metric Coordinator are important. In the management of change, the coordinator or manager needs the following characteristics:[1]

[1]Russell D. Archibald, Managing High-Technology Programs and Projects (New York: John Wiley & Sons) 1976.

Figure 7-1

Membership of the Metric

Policy Group

Recommended:

1) Deputy Chief of Staff for Logistics
2) Deputy Chief of Staff for Operations and Plans
3) The Comptroller of the Army
4) The Surgeon General
5) Chief of Engineers
6) CG U. S. Army Materiel Development and Readiness Command (Chairperson)
7) CG U. S. Army Training and Doctrine Command
8) Army Metric Coordinator

Conditional*

9) Deputy Chief of Staff for Personnel
10) The Adjutant General

*Conditional: Should sit on Group when matters of legitimate interest is being considered.

- Flexibility and adaptability;
- Preference for significant initiative and leadership;
- Aggressiveness, confidence, persuasiveness, verbal fluency;
- Ambition, activity, forcefulness;
- Effectiveness as a communicator and integrator;
- Broad scope of personal interests;
- Poise, enthusiasm, imagination, spontaneity;
- Able to balance technical solutions with time, cost, and human factors;
- Well organized and disciplined;
- A generalist rather than a specialist;
- Able and willing to devote most of his time to planning and controlling;
- Able to identify problems;
- Willing to make decisions;
- Able to maintain proper balance in the use of his time.

Due to the unique nature of metrication, the Metric Coordinator should possess additional qualities, to ensure a successful conversion. These qualities are:

- The entrepreneurial or self-starting spirit;
- Enthusiasm approaching an evangelistic attitude;
- High enough status (rank) to command an audience from Army top level management when desirable and permit a relatively informal relationship;
- A high tolerance for ambiguity and conflict;
- Negotiation skills;
- Ability to interact meaningfully with individuals at diverse levels and from diverse backgrounds (civilian as well as military):
- A high degree of awareness and capability for information/public relations activities.

The Metric Coordinator's power and ability to accomplish his missions will be based on his authority as well as his personal characteristics. Metrication involves a diversity of tasks--and much may be accomplished through informal means. Thus the characteristics of the Metric Coordinator described above are crucial. When a Metric Coordinator is selected, care must be taken to situate him organizationally so that he has sufficient authority and to select an individual who is dynamic enough to accomplish these difficult tasks.

In order to carry out the diverse responsibilities described above, the Metric Coordinator must be established at a position high in the organization to enable him to effectively cross organizational lines and have access to the influential individuals in the Major Army Commands and Major Subordinate Commands. High placement on the organizational chart will convey the authority to carry out his tasks.

An assessment of the roles and functions of the Army Metric Coordinator might suggest the appropriateness of using a Program/Project Manager approach, with the Army Metric Coordinator as the PM. We do not believe this is the most effective approach. Our reasoning is discussed below.

Management experts suggest that there is no single form of project management.[2] The concept is elastic and encompasses a range of forms. At one end of the spectrum is the individual project organization, which consists of only the project manager, who has no activities or personnel reporting directly to him. A second form is the staff project organization, where the project manager

---

[2]See, for example: Richard A. Johnson, Fremont E. Kast and James E. Rosenzweig, The Theory and Management of Systems (New York: McGraw-Hill Book Company) 1973; Fred Luthans, Introduction to Management: A Contemporary Approach (New York: McGraw-Hill Book Company) 1976; Brian Twiss, Managing Technological Innovation (New York: Longman Inc.) 1974.

is provided a small staff for project activities, but the primary functional project tasks are performed by the traditional line departments. A third variation is the intermix project organization. Under this form, the project manager has staff personnel and selected primary functional heads reporting directly to him. A fourth form is the aggregate project organization. The project manager has all personnel necessary for the project, staff and functional line, reporting directly to him.

With respect to the U.S. Army, AR 70-17, "System/Program/Project Product Management", specifies the conditions and practices for project management of materiel development. In general terms, it foresees the need for a project manager type of organization whenever centralized, intensive management is required. The PM defined in AR 70-17, generally has clearly defined authority, often line authority. Thus the PM under AR 70-17 would approximate the third or fourth form discussed above.

While metric conversion may require intensive management, both foreign and domestic experiences have repeatedly and strongly demonstrated that centralized decision-making is not effective with respect to metrication. The success of metrication has been dependent upon allowing the "doers" to do the planning and to make decisions on how best to metricate within their normal responsibility areas. The "doer" is the decision-maker who decides if and when to metricate a particular item. The Metric Coordinator's role is to facilitate that decision-making process, <u>not</u> to make the decision. To employ a centralized Program/Project Management approach as defined in AR 70-17 is directly counter to successful metrication experience evaluated in the course of the study.

A second weakness of the PM approach with respect to metrication is the concept of urgency which frequently underlies the use of a PM.[3] To imply that metrication is urgent is counter to

[3] See Fred Luthans, <u>Introduction to Management: A Contingency Approach</u> (New York: McGraw-Hill Book Company) 1976, p. 346-7.

the strategy of metricating on a timely, evolutionary, least-cost basis.

In summary, while metrication management and project management have several characteristics in common, project management, as defined in AR 70-17, is not appropriate as a means of managing metrication on a timely, least-cost basis.

7.3.3 Ad Hoc Working Groups

The foregoing discussion has examined the need for a Metric Coordinator whose major role in Army metrication is as a facilitator. However, the problems of metrication cross functional and organizational lines and some method must be devised for bringing together individuals with common interests and problems. Foreign and domestic experiences indicate that the use of ad hoc working groups and task forces to deal with specific problems is the best approach. The use of ad hoc, informal working groups ensures that the group will not become imbedded permanently in the organizational structure.

The membership of the ad hoc working groups or task forces would consist of individuals with line authority. The ad hoc groups would draw upon the knowledge and expertise of individuals involved in the day-to-day tasks of metrication in conjunction with regular line responsibilities. Ad hoc working groups would be assembled to deal with a problem or issue which crosses organizational lines. For example, standards development decisions impact a number of organizational entities. In order to capitalize on metrication benefits such as rationalization, Army usage of rationalized sizes must be compatible internally as well as with national and international standards wherever possible. Decision-makers must have sufficient information to assure that benefits are maximized. An ad hoc working group on standards and specifications (or a class of standards and specifications such as those for aerospace uses) may be useful. Other ad hoc groups might be formed to deal with training, ADP, logistics, briefings to industry, advice to small business, metrication planning and/or coordination and evaluation.

The use of ad hoc working groups also offers an advantage in bringing together, in one place, individuals with common metrication problems, on a periodic basis, if necessary. Considerable research shows that face-to-face exchange of ideas is the most successful means of technical problem solving. With periodic personal contact, other direct means of communication such as the telephone will more likely be used in the interim.

7.4 Recommendations on Summary of Organizational Elements

In summary, the foregoing discussion has taken a normative approach to the key elements of the Army metrication organizational structure and the roles and functions of each organizational entity. The recommendations developed are based on our knowledge of foreign and domestic experiences and practices and the U. S. Army organizational structure. The key recommendations of the foregoing discussion are as follows:

1) Primary responsibility for U. S. Army metrication should be assigned to the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA).

2) DARCOM should be assigned the "lead department" role, and CG DARCOM should be delegated major Army metrication responsibilities.

3) The high level, dedicated metrication organization should consist of:

   a. A metric coordinator, hereafter referred to as the DA Metric Coordinator (DAMC).

   b. A small dedicated staff to assist the DAMC. The DAMC plus his staff will be referred to as the DA Metric Office (DAMO).

   c. A high level metric policy group hereafter referred to as the DA Metric Advisory Group (DAMAG).

4) DCSRDA should not have membership on DAMAG. The Chairman of the DAMAG should report directly to DCSRDA.

5) CG DARCOM should chair the DAMAG.

6) The DAMC should report directly to the Chairman of the DAMAG.

These conclusions and recommendations provide the basis for the following discussion which deals, in specific terms, with organizational and physical location of the DAMO.

7.5 Physical and Organizational Placement of the DA Metric Office

The physical location of the DAMO is of interest since frequent personal contact will facilitate both formal and informal communication of metrication information. Recognizing the key metrication roles to be played by senior individuals at both HQDA and DARCOM, the prospect of staffing an office at both locations (i.e., by splitting the DAMO) comes immediately to mind. Easy physical access to senior individuals responsible for metrication at these two headquarters would certainly be an advantage. However, because the DAMO is envisaged to be small, it is likely that it would not remain viable. If DAMO were physically split the result would be ineffectiveness, or augmentation at one or both locations by full or part-time staff members (at increased cost). Coordination problems between the two halves would increase with staff increases. Duplication of effort and rivalry would very likely follow; the DA Metric Office, as a single identifiable entity, would cease to exist. For these reasons, subdivision of the DAMO is concluded to be unsuitable.

With the conclusion that the DAMO should not be split, the office could either be located at HQDA in the Pentagon or at HQ DARCOM. Both of these options appear reasonable and will be evaluated below, along with options for organizational placement.

Organizational placement of the DAMO is also very important, because authority is linked to position on the organizational chart. As discussed earlier, the DAMC and his staff (DAMO) are temporary. The DAMC will have little line authority but must have access to the Major Army Commands in order to carry out his functions. In developing organizational placement options, the recommendations made earlier have been adhered to, along with the following criteria:

- o Metrication effectiveness, as adduced pragmatically from foreign and U. S. industrial experience, must be assured.

  Foreign and domestic practice has provided a wealth of information on the types of organizational structures which are effective for metrication. In evaluating various organizational options for the Army, the characteristics of successful metrication organizations both here and abroad have guided the assessment.

- o The DAMC/DAMO must be tied closely to the highest Army organizational levels, specifically HQDA and DARCOM.

  Foreign and domestic experience have clearly demonstrated that high level interest is essential to successful, cost-effective metrication. To locate the DAMO at a level lower than HQDA or HQ DARCOM will severely jeopardize Army metrication.

- o The structure of the metrication organization must be compatible with accepted Army organizational concepts and the current Army structure (disregarding, for the moment, the provisions of AR 700-1).

  To adopt a metrication organization which conflicts with the standard organizational concepts and practices may create more problems than it solves since its roles, authority and relationship to the regular organization could be unclear.

In consonance with the recommendations and constraints discussed above, several options can be identified with respect to reporting chains for the DAMC. These options are for the DAMC to report to:

1) HQDA (DSCRDA) only
2) HQDA (DCSRDA) and CG DARCOM
3) HQDA (DCSRDA) and Chairperson DAMAG
4) CG DARCOM only
5) CG DARCOM and Chairperson DAMAG
6) Chairperson DAMAG only

Figure 7-2 displays, in matrix form, the organizational options defining all reasonable reporting chains for the DAMC and physical locations of the DAMO. For instance, Column 1 indicates that the DAMC could report only to HQDA (DCSRDA) and that the DAMO could be located at either DA or DARCOM Headqarters. The matrix in Figure 7-2 indicates twelve options for organizational and physical placement of the DAMC/DAMO. Clearly not all options are equally desirable or likely to be effective. Thus an assessment must be made to determine which options are the best.

Each cell is divided to permit two assessments to be shown. The letter appearing in the upper right corner of each ce-l represents a judgment of the metrication effectiveness of each option, i.e., how well it could be expected to work, based on foreign and U. S. industrial experiences investigated and reported in earlier chapters of this study.

The assessment appearing in the lower left corner of each cell represents a judgment of the compatibility of the option with current Army organizational concepts, as gleaned from AR 10-5 and other Army Regulations. A structure which is familar and workable is deemed more compatible than one which is unusual or untried.

Since the objective is to identify those options which are both most effective for metrication and most compatible with Army organizational concepts, the next step is to eliminate those options that received an assessment of Low (L) for either effectiveness or compatibility. This done, only the following options emerge as warranting further analysis:

Option 1: Locate the DAMO at DARCOM Headquarters, with the DAMC reporting to both DCSRDA and the Chairperson, DA Metric Advisory Group (DAMAG)

Option 2: Locate the DAMO at DARCOM Headquarters, with the DAMC reporting to both CG DARCOM and Chairperson, DAMAG.

Option 3: Locate the DAMO at DARCOM Headquarters, with the DAMC reporting only to Chairperson, DAMAG.

FIGURE 7-2

OPTIONS FOR ORGANIZATIONAL PLACEMENT OF THE DAMC/DAMO

DA METRIC COORDINATOR REPORTS TO--

Physical Location of DA Metric Office	HQDA Only	HQDA and DARCOM	HQDA and DAMAG	DARCOM Only	DARCOM and DAMAG	DAMAG Only
HQDA Pentagon	H / L	L / L	L / M	L / L	L / L	L / L
HQ DARCOM Alexandria	M / L	M / L	M / H	H / L	H / M	H / H

Key to Cell Assessments:

Compatibility with Army Organizational Concepts	Effectiveness for Metrication

Abbreviations:

HQDA	=	Designated Staff Officer, Army Staff (DCSRDA)
DARCOM	=	Commanding General, DARCOM
DAMAG	=	Chairperson, DA Metric Advisory Group
DAMC	=	DA Metric Coordinator
DAMO	=	DA Metric Office
H	=	High
M	=	Moderate
L	=	Low

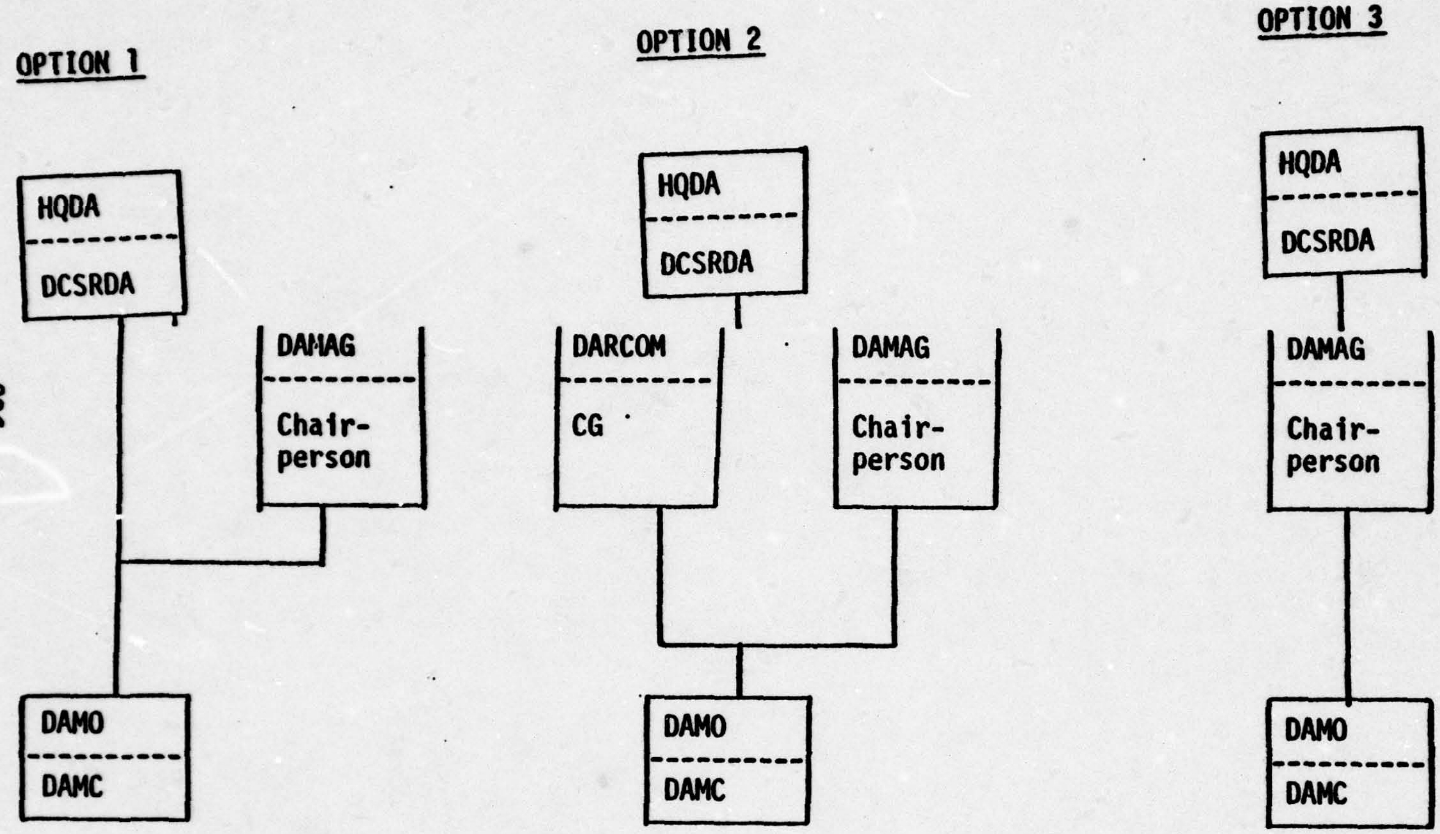
For clarity, structural organizational diagrams are given in Figure 7-3 for each of the three remaining options. Note that all three options exhibit certain common characteristics as a result of constraints and premises imposed and discussed earlier in this chapter. Common characteristics which should be borne in mind are: The DAMO is associated with the highest Army organizational levels; the DAMC reports to the Chairperson DAMAG; the DAMO is not subdivided; and the DAMC, by virtue of his terms of reference and title (Department of Army Metric Coordinator), is authorized access to members of any Army Command. While all three options have these characteristics in common, each option has several unique features. It is these unique features that must be evaluated to determine which option is the most appropriate for metrication.

Under Option 1, the DAMC reports to both HQDA (DCSRDA) and the Chairperson of the DA Metric Advisory Group. Direct access to HQDA may be advantageous in that metrication information could be exchanged on a frequent, rapid, and personal basis; thus assuring that high level management is fully informed. The direct link to DCSRDA may provide the DAMC with additional implied authority. The option could, however, result in serious conflicts and misunderstandings among the three principals involved. The DAMC, serving two masters, could find himself in an uncomfortable position, and his effectiveness could be impaired. To reduce the possibility of conflict, terms of reference outlining the DAMC's relationship vis-a-vis HQDA (DCSRDA) and the Chairperson of DAMAG would have to be carefully drawn; the terms of reference would necessarily constrain the DAMC's relationship with HQDA in order to preserve the authority delegated to the Chairperson of DAMAG.

Under Option 2, the DAMC reports to both CG DARCOM and the Chairperson DAMAG. Since metrication will impact DARCOM so significantly, this reporting chain appears at first to be reasonable. Under closer scrutiny, however, its appropriateness becomes suspect; why should the DAMC report to CG DARCOM, a Major Army Command? Could this not subordinate the legitimate metrication concerns of TRADOC

FIGURE 7-3

OPTIONS FOR ORGANIZATIONAL PLACEMENT OF THE DAMO



(or other Major Army Commands or Army Staff elements) to those of DARCOM? The effect could be to place DARCOM in a more favored (i.e., more authoritative) position than intended, with the further risk that the DAMO could become a de facto DARCOM Metric Office. Terms of reference, defining the DAMC's relationships with CG DARCOM and Chairperson DAMAG, would be required.

Under Option 3, the DAMC reports only to the Chairperson DAMAG. This arrangement is appealingly simple. It is also consistent with successful U. S. industrial practice and with foreign metrication practice in industry and government agencies. Because the DAMC is not linked to the permanent organizational structure, dissolution of the position at the end of the metric transition should be uncomplicated.

While any of these three options is viable and would work, one may work better than another. Therefore, it is useful to compare the three options in order to select the option which appears to be the most advantageous.

The relative advantages and disadvantages of each option, compared to the other two, are summarized in Figure 7-4. As Figure 7-4 illustrates, Options 1 and 3 offer significant advantages, while Option 2 has no such points in its favor. Additionally, the advantage associated with Option 1, i.e., direct access to HQDA, is mitigated by the risk of conflict resulting from a dual reporting chain.

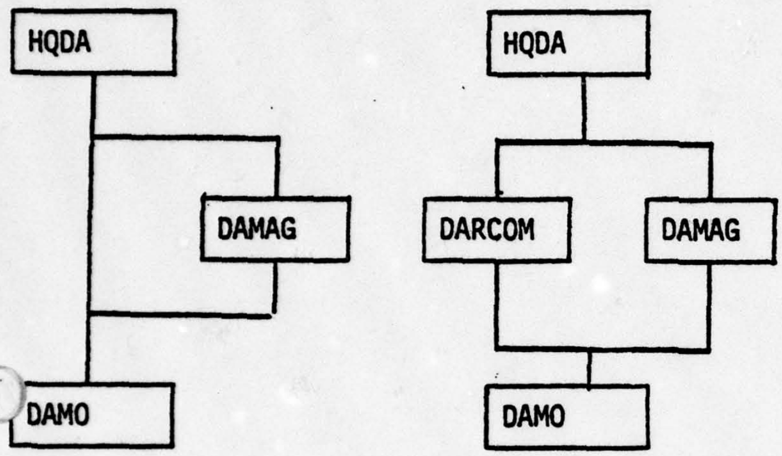
Option 2, which offers no advantage, also suffers from the hazards of the dual reporting structure, even if CG DARCOM concurrently serves as Chairperson DAMAG. The effectiveness of the DAMC in dealing with DA metrication would be diminished in proportion to the DARCOM metrication responsibilities imposed on the DAMC by CG DARCOM. With the limited resources envisaged, the DAMO could very quickly become, in effect, the DARCOM Metric Office.

Option 3, however, is not subject to these disadvantages, and it offers clear advantages over the other options: simplicity and demonstrated effectiveness. Option 3 is therefore selected as the recommended structure for Army metrication at the highest Army organizational levels.

FIGURE 7-4

COMPARISON OF OPTIONS FOR ORGANIZATIONAL PLACEMENT OF DAMC/DAMO

OPTION 1	OPTION 2	OPTION 3



	ADVANTAGES	
Direct ccess to HQDA	None	Simple Consistent with successful industrial/foreign practice

	DISADVANTAGES	
Conflicts possible with dual reporting chain	DARCOM's position more favored than intended DAMO could become DARCOM metric office Conflicts possible with dual reporting chain	None

7.6 Comparison of Current and Recommended Structures for the DA Metrication Organization

7.6.1 Introduction

Previous sections of this chapter have dealt with the Army metrication organization from a normative viewpoint, drawing heavily on successful U. S. industrial and foreign metrication experience, to derive pragmatically an appropriate metrication structure for the Army. The purpose of this section is to compare the recommended structure thus developed with the current Army metrication structure as outlined in AR 700-1 (See Annex F) by clearly juxtaposing differences in order to identify recommended changes to AR 700-1. Succeeding subsections address the major organizational elements, the principals involved, and their reporting chains. It should be borne in mind that the discussion of elements, principals, and chains pertains specifically to the metrication organization; normal organizational structures (i.e., those not related to metrication) remain unaltered.

7.6.2 Major Organizational Elements

Both the current and recommended Army metrication structures focus on the highest organizational levels, namely HQDA and MACOM (including MACOM staff). As may be seen in Figure 7-5, major metrication elements are the same for both the current and recommended structures.

7.6.3 Principals in the Army Metrication Organization

Figure 7-6 shows the principals identified in AR 700-1 and in previous sections of this chapter. Two differences are apparent: the absence of CG DARCOM in the recommended structure, and the DAMO/DAMC change with respect to the executive staff.

Under both the current and recommended structures, CG DARCOM is designated ex officio as Chairperson of the DA Metric Advisory Group. As a member of DAMAG, CG DARCOM represents DARCOM (in the same fashion that, for instance, CG TRADOC represents TRADOC), but as Chairperson he acts for the DAMAG as an entity. Drawing

FIGURE 7-5

MAJOR ORGANIZATIONAL ELEMENTS FOR ARMY METRICATION

Organizational Level	Organizational Elements Current*	Organizational Elements Recommended
HQDA	HQDA	HQDA
MACOM	DARCOM	DARCOM
	DAMAG	DAMAG
Executive Staff	DAMO	DAMO

Abbreviations

DAMAG - DA Metric Advisory Group
DAMO - DA Metric Office
DARCOM - Army Materiel Development and Readiness Command
HQDA - Headquarters, Department of the Army
MACOM - Major Army Commands

*Reference: AR 700-1.

FIGURE 7-6

PRINCIPALS IN THE ARMY METRICATION ORGANIZATION

Organizational Level	Principals: Current*	Principals: Recommended
HQDA	DCSRDA	DCSRDA
MACOM	CG DARCOM	
	Chairperson DAMAG	Chairperson DAMAG
Executive Staff	DAMO	DAMC

Abbreviations

Chairperson DAMAG - Chairperson DA Metric Advisory Group
DAMC - DA Metric Coordinator
DAMO - DA Metric Office

*Reference: AR 700-1.

this distinction tends to clarify metrication reporting chains discussed in Section 7.6.4.

AR 700-1 is ambiguous with respect to the DAMO. An office cannot develop plans or sit as a member of DAMAG (as prescribed); it is clear that a person is envisaged, although none is identified in AR 700-1. However, such a person is identified (the DA Metric Coordinator) as a vital part of the recommended structure and head of the DA Metric Office.

7.6.4 Reporting Chains for the Army Metrication Organization

The current and recommended metrication reporting chains among the principals are given in graphic and tabular form in Figures 7-7 and 7-8. Differences appearing in each row of the table in Figure 7-8 are discussed in the paragraphs which follow.

In the first row, it will be seen that Chairperson DAMAG, rather than CG DARCOM, reports to DCSRDA under the recommended structure. This is consistent with the concept that the DAMAG serves in an advisory capacity to the decision-maker, DCSRDA.

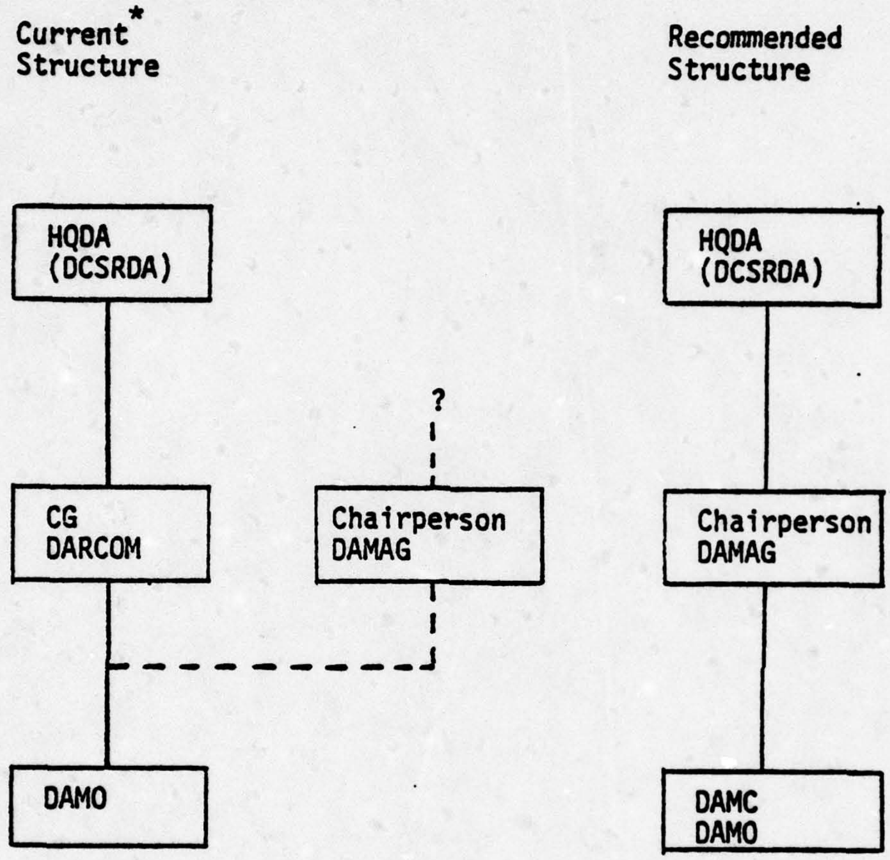
In the second row, no metrication links are ascribed to CG DARCOM under the recommended structure. CG DARCOM's normal organizational links are unaffected by metrication, and he would certainly be in the reporting chain of the DARCOM metrication organization; however, he should not, in his "DARCOM Hat," be in the Army metrication organization at the HQDA/MACOM level.

In the third row, the person reporting for the DAMO to the Chairperson DAMAG is identified as the DAMC under the recommended structure. AR 700-1 does not explicitly indicate to whom Chairperson DAMAG reports, except by implication that CG DARCOM, acting as Chairperson, reports to HQDA. Under the recommended structure, the relationship of Chairperson DAMAG to DCSRDA is made explicit.

In rows 4 and 5, the DAMC, a position not recognized in AR 700-1, reports to Chairperson DAMAG under the recommended structure since the DAMC serves as the Chairperson's staff officer for

FIGURE 7-7

ORGANIZATIONAL STRUCTURES FOR ARMY METRICATION



Abbreviations

DAMAG - DA Metric Advisory Group
DAMC - DA Metric Coordinator
DAMO - DA Metric Office

*Reference: AR 700-1.

FIGURE 7-8

REPORTING CHAINS FOR THE ARMY METRICATION ORGANIZATION

	Who Reports to the Principal?		To Whom Does the Principal Report?	
Principal	Current[1]	Recommended	Current[1]	Recommended
DCSRDA	CG DARCOM	Chairperson DAMAG	Army Chief of Staff	
CG DARCOM	DAMO	2	HQDA(DCSRDA)	2
Chairperson DAMAG	DAMO[3]	DAMC[3]	4	HQDA(DCSRDA)
DAMC	5	6	5	Chairperson DAMAG
DAMO	6	6	CG DARCOM	7

NOTES

1 - Reference: AR 700-1.
2 - Not relevant to the Army metrication organization; normal reporting chains remain intact.
3 - Provides secretariat to DAMAG.
4 - AR 700-1 is not clear on this point.
5 - DAMC not recognized in AR 700-1.
6 - No formal reporting chain; informal contacts only.

Army metrication. Apart from his own staff in the DAMO, there are no formal organizational links to the DAMC since he has no line authority.

7.6.5 Summary

In summary, it may be concluded that the current and recommended structures of the Army metrication organization differ mainly in the reporting chains among the principals (especially CG DARCOM vis-a-vis Chairperson DAMAG), and the explicit designation of a DA Metric Coordinator as head of the DA Metric Office. Annex M contains changes to AR 700-1 necessary to implement the recommended structure. The changes incorporate structural adjustments discussed in this section, as well as functional adjustments developed elsewhere in this chapter.

7.7 Metrication Organizations of Major Army Commands, Major Subordinate Commands, and System/Program/Project/Product Managers

The preceding discussions have dealt with the functions and structure of the Department of the Army metrication organization. An effective metrication organization at the highest Army levels is essential to a coordinated, least cost transition; for the same reasons, organizations or informal mechanisms for metrication are necessary at subordinate Army levels.

Metrication organizations at subordinate levels should be similar to the DA metrication organization in terms of function. The metrication organization should perform a staff function, not line. It should support and assist line managers by providing metric information and interfacing with those of other commands and with the DA metrication organization. Personnel should be assigned responsibilities in the metrication organization which are compatible with, or supportive of, their normal responsibilities, i.e., assignments should be made on a collateral duty basis. (Dedicated metrication spaces would be inappropriate.)

Metrication organizations at subordinate levels may also be similar in form to the DA metrication organization,

but the precise form of the structure, however, should be tailored to suit the individual command. Army metrication organizations at subordinate levels may be likened to divisions of a corporation; division managers are responsible for their divisions and they frequently establish metrication organizations which are similar in form to those at corporate level and which include the following elements:

- An ad hoc, high level committee or task force to coordinate metrication efforts within the division, recommend metrication policies for division approval, and review metrication progress.
- A metric coordinator to serve as an executive officer to the high level committee and to deal with metrication on a day-to-day basis.
- Temporary, ad hoc groups of line personnel convened by the high level committee to address particular metrication issues as necessary.
- No dedicated (paid) metrication spaces.

The foregoing elements of an industrial organization appear to be appropriate for the larger Army commands, such as Major Army Commands and Major Subordinate Commands. For smaller Army organizations (Project or Product Managers, for instance), the form of the metrication organization may be less elaborate; for very small organizations, no metrication organization may be required. Total assimilation of metrication functions into normal activities, or informal mechanisms to assure that metrication functions are accommodated, may be sufficient.

As mentioned above, the precise form of the metrication structure is not critical, but depends on the particular needs of the command. Such things as the size of the command, the type of product produced or service performed, and the commander's organizational preferences are pertinent factors for consideration. The state and

rate of metric conversion of industries/companies with which the command deals may also affect the form of metrication organization adopted.

It should not be inferred that the metrication organization need be complex. A cost effective approach would dictate the simplest organization that would assure effectiveness. The burden of metrication should fall largely on those in line organizations whose normal responsibilities are affected by metric developments and activities.

In summary, metrication organizations perform the same function, whether at HQDA or subordinate levels. That function is, in essence, to support line management in the metric conversion process. The structural form which the metrication organization takes depends on the particular command, its needs and the desires of the commander. Typically, at the division level of a corporation, the structure consists of a policy committee, a metric coordinator, and ad hoc groups of line personnel temporarily convened to deal with particular metrication issues and problems; dedicated (paid) metrication spaces have not been found necessary. Such a structure appears to be appropriate for adoption or adaptation by the larger Army commands. The structural form could be streamlined for smaller commands to the point where no recognizable metrication organization exists at all, only informal mechanisms to assure that metrication functions are not overlooked.

CHAPTER 8

IMPLEMENTATION PLAN

The purpose of this chapter is to present recommendations on tasks for the Army Metrication Organization. As Chapter 6 discussed in some detail, the day-to-day tasks and the operational decisions regarding the use of metrics should be handled by the individuals with appropriate line management authority. The Army Metrication Organization is not a decision-making organization except in areas of broad guidance and the development of policy statements. The Army Metrication Organization's main function is to support the line managers.

The tasks included in the Implementation Plan focus upon the initiatives which must be taken by each of the principal Army metrication actions, to get Army metrication activities moving in a coherent manner. Currently, Army metrication activities are being carried out on an ad hoc, unplanned basis. As has been demonstrated, continued lack of planning will result in significant costs to the Army.

As noted above, task statements have been developed for each of the principal Army metrication actors, most of whom are identified in Chapter 7. The major problem which emerges is the question of which individual currently has a position which would allow him to stimulate high level interest in metrication. This is a significant question because although there are provisions in AR 700-1 to establish a metrication organization, this has not been done, indicating lack of appreciation of the urgency of metrication planning and implementation. In reviewing Army metrication activities, the Army member of the DoD Metrication Steering Group emerged as a likely candidate. In discussing the initial tasks, therefore, we will designate certain tasks for this individual. This is not

implying that he must necessarily be the only or the main actor. Several individuals within the Army have interest in metrication and could provide impetus to the conversion. We have designated the Army member of the DoD Metrication Steering Group for convenience and title but it should be borne in mind that other individuals with interest in metrication could carry out these tasks also.

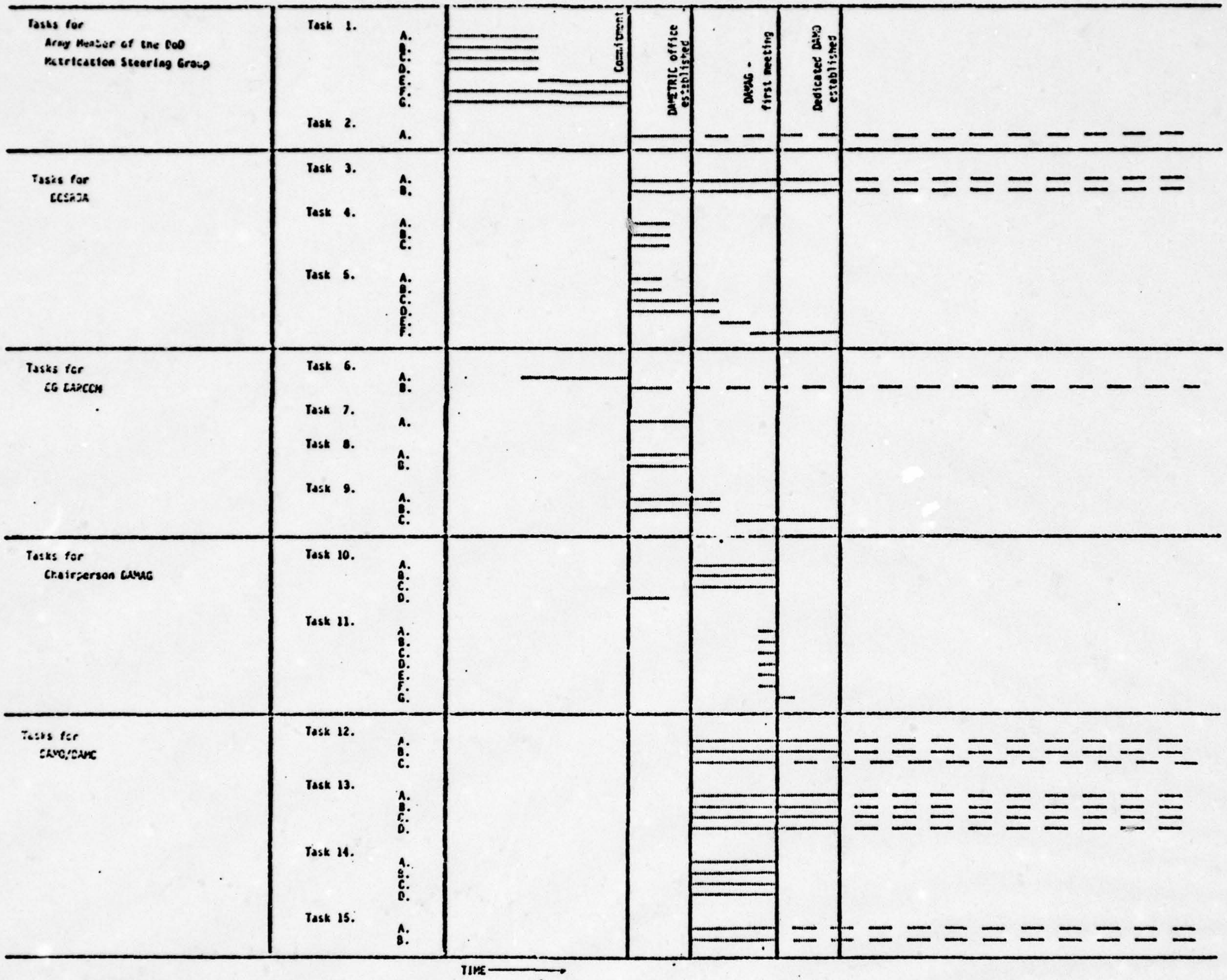
In Chapter 7, an organizational structure was recommended which would require some modification to AR 700-1. The tasks discussed in this chapter are the initial tasks and can be performed within the terms of AR 700-1 as it stands today. Tasks have been grouped together according to the main actor in carrying out the task. Figure 8-1 summarizes the tasks recommended here, and illustrates concurrence of task execution and major milestones in the early phases of metrication.

8.1 Tasks for Existing Metric Actors (e.g., Army Representative tc the DoD Metric Steering Group)

Currently within the Army, the DA Metric Office has not officially been established. However the Army member of the DoD Metrication Steering Group certainly has the unofficial position from which to initiate metrication efforts to get the Army metrication efforts into a more organized, planned direction. The discussions included in Section 8.1 focus on the tasks which the Army member of the DoD Metrication Steering Group should execute. As noted above numerous other interested individuals within the Army could also be involved in executing these tasks.

The major thrust of Tasks 1 and 2 is to create an awareness of impending metrication and secure a high level commitment to a planned conversion. While it is of interest who executes these tasks, more critical is that the tasks be accomplished. Who the major actors are is not really important.

FIGURE 8-1
IMPLEMENTATION PLAN FOR ARMY METRICATION ORGANIZATION



Task 1: Secure High Level Commitment to Army Metrication

Discussion

A pronounced, publicized commitment to metrication, by highest level management, is absolutely essential to a least-cost metric conversion. However, to date, this commitment does not appear to exist in the Army, and thus low priority is assigned to metrication. There does not appear to be a recognition at high levels of management that metrication is inevitable and that planning is required to assure a smooth transition. This is a critical task, without commitment, little can or will be done to prepare for and implement metric conversion.

Elements of the Task

A. Develop list of candidates for contact and briefing.

B. Distribute summary of FI Study to appropriate high level individuals including:

   1. Deputy Commanding General for Materiel Development

   2. Deputy Commanding General for Materiel Readiness

   3. Commanding General of DARCOM

C. Identify high level individuals who have demonstrated concern for metrication and enlist aid to develop entrees and lines of communication.

D. Prepare briefing materials for presentation to top management. Because interests and depth of knowledge regarding metrication will vary, consideration should be given to preparing modular materials which can be combined to suit each audience. Briefing should be concise and time efficient.

E. Brief to top management.

F. Prepare and present options and recommendations for:

   1. Metrication organization structure

   2. Responsibilities assigned to each element of the organizational structure

3. Changes to AR 700-1 to support recommendations

4. Interim measures that can be taken under provisions of AR 700-1

5. Strategy options

G. Provide drafted implementing documents where necessary, for instance, present Change 1 to AR 700-1 for review and concurrence as appropriate.

Action Office

Army member of the DoD Metrication Steering Group.

Task 2: Ensure that Highest Level Commitment to Army Metrication is Made Known Throughout the Army

Discussion

That high level commitment to metrication is essential has been demonstrated by foreign and domestic experience. Equally important is an awareness of this commitment throughout the organization. Once Army commitment to metrication is established, the commitment must be publicized through official as well as informal communications networks.

Elements of the Task

Informal publicizing of high level commitment through bulletins, newsletters, the Army-Air Force Times, and other existing house organizations.

Action Office

Army member of DoD Metrication Steering Groups and others who can use informal contacts to secure inclusion of metrication articles in Army publications.

8.2 Initial Tasks for the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA)

Currently under the provisions of AR 700-1, DCSRDA has major responsibilities in Army metrication, as he would under the recommendations included in this report. The following discussion presents the major initial metrication tasks for DCSRDA.

Task 3: Promulgate Commitment

Discussion

While DCSRDA may support Army metrication, a firm, clear statement of the importance of metrication is essential and all elements of the Army must be aware of this HQDA level commitment.

Elements of the Task

A. Identify and utilize formal channels for issuing formal statement of commitment.

B. Incorporate metric issues/statements in informal activities, briefings, communications.

Action Office

DCSRDA

Task 4: Issue Guidance to the DA Metric Advisory Group

Discussion

The DA Metric Advisory Group (DAMAG) under the terms of AR 700-1, as well as the proposed modifications, has major responsibility for the development of policy and guidance for U. S. Army metrication efforts. Initially it may be valuable for the Group to be guided by statements from DCSRDA with respect to reporting procedures, time frames, and issues to be considered initially by the Group. Issuing guidance to the DA Metric Advisory Group is an essential action which serves to reinforce the commitment statements made at HQDA level.

Elements of the Task

A. Establish reporting requirements and procedures for DAMAG.

B. Prepare list of major issues which need immediate consideration (e.g., metrication strategy options).

C. Convey direction and guidance to the Chairman and membership of DAMAG.

Action Office

DCSRDA. DCSRDA may require support and information from the DA Metric Office or Army representative to DoD Metrication Steering Group.

Task 5: <u>Initiate Actions to Establish the Army Metrication Organization</u>

<u>Discussion</u>

Establishment of a dedicated metrication organization has been recommended, and can be effected under the terms of AR 700-1 as it stands today. Proposed revisions to the AR 700-1 support a dedicated metrication organization more explicitly. The decision on the metrication organization to be utilized, and actions establishing the organization, is essential to metric conversion on an orderly, cost-effective basis.

<u>Elements of the Task</u>

A. Issue direction for designation of membership in DAMAG.

B. Initiate actions to establish DAMO.

C. Assess recommendations regarding metrication organization.

D. Concur in recommended changes to metrication organization.

E. Approve necessary changes to AR 700-1.

F. Institute actions to secure personnel (spaces, funds, etc.), for dedicated metrication staff, including the DA Metric Coordinator.

<u>Action Office</u>

DCSRDA, who may require supporting information, documentation from Major Army Commands, especially DARCOM, or from the Army member of the DoD Metrication Steering Group.

8.3 Initial Tasks from the Commanding General, U. S. Army Materiel Development and Readiness Command

As the element of the Army most likely to be affected immediately and profoundly by metrication, DARCOM has a pivotal role to play in the Army's conversion. Accordingly, CG DARCOM has several key tasks to initiate metrication activities. His tasks result from specific responsibilities to HQDA as well as unique DARCOM oriented tasks.

Task 6: Promulgate Commitment to Metrication

Discussion

It is essential for the high-level individuals involved, as major actors in metrication, to make a statement of commitment. Recommendations by CG DARCOM could be a preliminary to securing commitment from DCSRDA. In consonance with Army commitment to metrication CG DARCOM will promulgate commitment to activate DARCOM.

Elements of the Task

A. Convey metrication recommendations to DCSRDA.

B. Promulgate commitment to subordinates.

Action Office

CG DARCOM, perhaps with support and/or background information from DA Member of the DoD Metrication Steering Group.

Task 7: Establish the DA Metric Office (DAMO), Under the Terms of AR 700-1 As it Stands Today

Discussion

To issue a statement of commitment and not act would serve no real purpose. Statements should be enforced by action. The AR 700-1, in its present form, provides the authority to CG DARCOM to establish a DA Metric Office. An early establishment of a DA Metric Office is critical. It is a positive step which will sustain the momentum of the initial move towards metrication.

Elements of the Task

While the task will not be broken down into elements, several considerations should be mentioned. First, if difficulties exist in immediately securing personnel spaces for a dedicated metrication staff, the assignment of metrication responsibilities as collateral duly must be exercised as an expedient alternative. While this is not the optimum approach, maintenance of momentum is essential. The establishment of the DAMO must be done officially and must be widely publicized. Additionally, provision should be made to assure that those assigned to metrication are not overburdened by other duties.

Action Office

CG DARCOM

Task 8: Activate DARCOM Metrication Activities

Discussion

Backing commitment statements with actions is essential to a sustained metrication. In addition to establishing the DA Metric Office, activation of a DARCOM metrication organization and activities is essential. AR 700-1 can be interpreted to indicate that DARCOM is the Army's "lead department". Active steps to support metrication within DARCOM will reinforce commitment and provide an example to other Major Army Commands.

Elements of the Task

A. Appoint a DARCOM metric coordinator. At least initially, one option is to appoint either the head or a member of the DA Metric Office Staff as the DARCOM coordinator.

B. Issue guidance to the DARCOM Major Subordinate Commands.

Action Office

CG DARCOM

Task 9: Support Activities to Secure Dedicated DA Metric Office

Discussion

It is highly recommended that there be a dedicated metrication staff in the DAMO. This will be particularly important through the first few years of transition. Several obstacles currently exist to securing a dedicated staff as recommended.

Elements of the Task

A. Concur in metric organization.

B. Concur in changes to AR 700-1.

C. Initiate or support, as appropriate, measures to obtain spaces for the DAMO and personnel to fill them.

Action Office

CG DARCOM

8.4 Initial Tasks for the Chairperson of the DA Metric Advisory Group

The DA Metric Advisory Group fills an important role in Army metrication by recommending policy, reviewing progress and recommending corrective actions or changes. The Chairperson has a significant role to play in supporting the activation of Army metrication, particularly initially. The following discussions point out the major actions to be taken by the Chairperson of the DA Metric Adivsory Group (DAMAG) early in the transition.

Task 10: Prepare Meeting of the DA Metric Advisory Group (DAMAG)

Discussion

The first meDAMAG is very important for it sets the tone for the futufore, the first meeting should be well prepared, wd and productive. This task looks to the key factors and the first meeting.

Elements of the 1

A. Task DAre an agenda for the first DAMAG meeting items to be considered may include:

1. Stcommitment by Chairperson and by present at meeting.

2. Adre procedures governing the fuf the Group.

3. In of metrication strategy alterna-ticision and development of recom-me

B. Task DAre short briefing on metrication issues eeting of DAMAG.

C. Task DAre working papers on strategy developview by DAMAG.

D. Obtain of the Group by name.

Action Office

ChairpersonMetric Advisory Group supported by DAMO.

Task 11: Conduct First Meeting of DA Metric Advisory Group

Discussion

As mentioned before, a statement of commitment is essential for successful metrication, but a statement which is not supported by guidance and action is not likely to be effective. Conducting a meeting of the DA Metric Advisory Group, shortly after announcement of the commitment, will serve to reinforce the statement.

Elements of the Task

A. Deliver statement of commitment by Chairperson and DCSRDA if present

B. Obtain consensus on administrative procedures to be followed.

C. Conduct metrication briefing.

D. Distribute/discuss working papers on metrication strategy options

E. Seek consensus on metrication strategy to be recommended to DCSRDA. (If consensus cannot be reached at this meeting, schedule as an agenda item for decision at next meeting.)

F. Discuss agenda items for next meeting and schedule next meeting.

G. Publish some concrete resolution from the meeting.

Action Office

Chairperson of the DA Metric Advisory Group.

8.5 Initial Tasks for the DA Metric Office (and the DA Metric Coordinator)

The DA Metric Office (DAMO), and the DA Metric Coordinator, will play a significant role in Army metrication on a day-to-day basis. This office will serve as an information center, an advisory center and as secretariat to the DA Metric Advisory Group. The DAMO, headed by the DA Metric Coordinator, will have many demands placed upon it early in the transition, because many elements of the Army are not informed about metrication and its implications.

The following discussions highlight the key tasks for DAMO (and DAMC) early in the transition. The successful initiation (and completion) of these tasks is essential to implementing metrication on a timely and effective basis.

Task 12: Establish Army-Wide Metrication Communication Channels

Discussion

One of the primary functions of DAMO throughout metrication is to facilitate the communication of metrication information. The focus of this task is to determine the principals and to activate the metrication communication network.

Elements of the Task

A. Update existing list of Army metric coordinators. A current listing should be prepared, with commercial and autovon numbers. The list might also include areas of interest and other pertinent information so that individuals can readily identify others with like interests.

B. Establish contact with Army metric coordinators. Initial face-to-face contact is highly desirable whever possible. Written communication is least likely to be effective so other alternatives should be exercised where possible.

C. Maintain contact through frequent communications.

Action Office

DAMO/DAMC.

Task 13: Establish (or Expand Existing) Information Base

Discussion

Within the Army, access to internal and external metrication information and experience is inadequate. As a central source of Army metrication information, one of DAMO's first essential tasks is to establish an up-to-date collection of metrication information which can be readily accessed. Information collected should focus on all aspects of metrication of interest to the Army. The information providing task can be approached in two ways. In some cases it will be essential to have the information in hand--and specific information must be collected and maintained by DAMO. In other cases, until a specific need for detailed information is expressed, DAMO could identify sources, but not maintain the data in-house.

Elements of the Task

A. Determine the metrication status and plans of internal and external elements. (This would include Major Army Commands, DoD, Other Services, Army Staff, U. S. industry, etc.).

B. Collect information from the field on areas of concern, needs for information.

C. Determine which external metrication publications newsletters, etc. are useful and recommend that appropriate Army organizations obtain subscriptions.

D. Determine need for in-house publications, newsletters, etc. and begin arrangements for development and publication.

Action Office

DAMO/DAMC.

Task 14: Support DA Metric Advisory Group

Discussion

As noted in Task 10, the first meeting of the DA Metric Advisory Group is crucial. DAMO will have to prepare a great part of the background information and proposed agenda items to support the objective of an effective, fruitful first meeting.

Elements of the Task

A. With the concurrence of the Chairperson of the DA Metric Advisory Group, develop an agenda for the first meeting.

B. Prepare briefing materials and point papers on metrication strategy options.

C. At the direction of the Chairperson, perform other support actions as necessary.

D. Participate in DAMAG meeting.

Action Office

DAMO/DAMC.

Task 15: Establish List of Priority Items for Action and/or Study

Discussion

Metrication will be a complex task involving numerous Army organizational entities. Many demands will be made on DAMO but not all can be handled immediately due to the small staff. Thus priorities must be assigned to various metrication activities. Priorities must be developed on the basis of need in the field. Based on this list of priorities, DAMO can identify areas where policy and guidelines need to be developed, ad hoc working groups would be useful, and information gathering efforts should focus.

Elements of the Task

A. Through contact with various elements of the Army, lists of key or critical areas of interest should be developed.

B. The key areas of interest should be ranked according to importance. A list of priorities should be presented to the Chairperson DAMAG for approval.

Action Office

DAMO/DAMC.